

California Coastal Kelp Resources

Monterey Bay National Marine Sanctuary

Summer 2000

Final Report

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by

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California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Bolinas Lagoon to Pt. Estero
Summer 2000

Principle Findings

The principle findings from the 2000 Monterey Bay National Marine Sanctuary kelp resource inventory were summarized, by CDF&G kelp bed numbers, as follows:

- 1) 2000 kelp resource extent,
- 2) 1999 kelp resource extent, and
- 3) Comparisons of the 1999 and 2000 sanctuary-wide coastal kelp resource.

1) Summary of the 2000 Sanctuary-wide Kelp Resource Extent

The total 2000 surface kelp canopy resource, within the MBNMS (CDF&G kelp beds 208-225), occupied canopy/planimeter areas of 17.051 sq. mi. and 24.663 sq. mi., respectively. The relative density index was measured at .71.

2) Summary of the 1999 Sanctuary-wide Kelp Resource Extent

The total 1999 surface kelp canopy resource, within the MBNMS (CDF&G kelp beds 208-225), occupied canopy/planimeter areas of 14.053 sq. mi. and 22.358 sq. mi., respectively. The relative density index was measured at .63.

3) Summary Comparisons of the 1999-2000 Sanctuary-wide Kelp Resource

The total sanctuary-wide kelp resource canopy area significantly increased ($p=.05$) from 14.053 sq. mi. to 17.451 sq. mi., which represented a 24% increase in surface canopy from that measured in 1999. The 1999-2000 total kelp bed planimeter area also significantly increased from 22.358 to 24.663 sq. mi., which represented a 10% increase in planimeter extent. The relative density index also significantly increased from .63 (1999) to .71 (2000).

Although virtually all canopies within the survey range showed an increase in surface extent, the greatest increase was observed within Monterey Bay itself (CDF&G canopies 222, 221 and 220). Increases in canopy areas of 120%, 206% and 66%, respectively, were noted. In addition, increases in planimeter areas of 59%, 33%, and 43%, respectively, were also observed within these canopies.

The only canopy to experience a substantial loss in surface extent was canopy 208 (Cambria to Pt. Estero), which was reduced by 24% in canopy area and 14% in planimeter area.

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(Section 6)

FILE: MBNMSK00.XLS (Excel 97 Format)

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**CALIFORNIA COASTAL
KELP RESOURCES**

Bolinas Lagoon
to
Point Estero

Section 1

Final Report

August 2000

CALIFORNIA COASTAL KELP RESOURCES
Monterey Bay National Marine Sanctuary
Summer 2000

Introduction

Along the California coast there is an abundant "kelp" resource assemblage present (brown seaweeds - Order Laminariales). The dominant, near shore, surface canopy forming species include *Nereocystis luetkeana* (bull kelp) and *Macrocystis pyrifera* (giant kelp). Although the individual species ranges are distinct, surface kelp canopies are present along the entire California coast from Crescent City to Imperial Beach (Abbot and Hollenberg 1976).

Each surface canopy, supported by air-filled pneumatocysts, is composed of individual plants that are attached to the bottom subtidal habitat by root-like "holdfasts." The vertical stipes, stretching from the sea floor to the surface canopy, provide critical habitat for numerous species of commercial and sport fish, invertebrates, marine mammals and related understory marine algae (Foster and Schiel 1985). Along the central California coast, 77 species of fish have been identified in kelp forests (Miller and Geibel 1973), and McLean (1962) identified 204 species of invertebrates in a predominately *Nereocystis luetkeana* kelp forest located south of Monterey. Prominent marine mammals, such as seals, sea lions and California sea otters, are also associated with this important near-shore habitat (Morejohn 1977).

In addition to its role as an essential marine habitat, coastal kelp canopies exhibit some of the highest primary productivities of any ecosystem on earth (Wheeler and Druehl 1986). This material is provided to the food chain in three ways: 1) directly, while the kelp plants are still attached, 2) indirectly, by providing detritus that is eaten after it has fallen to the bottom, and 3) by producing dissolved organic matter (DOM) that is food for many microorganisms (Mumford 1989). Kelp bed primary productivity within *Nereocystis*/*Macrocystis* beds has been estimated at 350-2,800 g carbon/m² (Wheeler 1990), placing them ahead of tropical rain forests, reefs and estuaries, warm temperate forests, and cultivated land with regard to their contribution to the overall food chain.

Nereocystis luetkeana occurs from Point Conception to the eastern Aleutian Islands (Druehl 1970), and is the dominant, surface canopy kelp north of Santa Cruz, California. Its hydrodynamic shape makes it especially well suited to high exposure, "open coast" environments (Foster and Schiel 1985). *Nereocystis* is predominately an annual (Abbot and Hollenberg 1976), although mature plants have been seen to persist for up to 18 months. Impressive growth rates of up to 10 cm per day have been observed in young plants, and the mature surface canopy reaches its maximum extent in July through October. Sporangial sori mature at the surface between May and December, drop from the blade, and sink to the sea floor before releasing their spores (Abbot and Hollenberg 1976).

Macrocystis pyrifera has a range in North America from Alaska to Magdalena Bay in Baja California (Abbot and Hollenberg 1976), and frequently forms thick canopies on rocky substrata at depths of from 6-20 meters. *Macrocystis* is a perennial, at least the basal holdfast and attached sporangial thalli, and develops its maximum surface canopy between May and October. *M. pyrifera* is the predominant canopy forming kelp in species in California south of Sandhill Bluff (Santa Cruz County), and in addition to providing essential marine habitat to hundreds of related species, is utilized commercially as well. Upwards of 140,000 tons wet weight of *M. pyrifera* are harvested annually from state-owned kelp beds for the purpose of extracting alginates and colloids widely used in industry and in the preparation and preservation of certain foods (Abbot and Hollenberg 1976).

Mixed canopies, containing both *Nereocystis* and *Macrocystis*, are present along much of the California coast-line from Sandhill Bluff (Santa Cruz County) to Port San Luis (San Luis Obispo County), and when these species co-occur, *Nereocystis* is most commonly found inshore and *Macrocystis* offshore (Foster and Schiel 1985).

The extent of the total kelp canopy occupied by each of these individual species is dynamic from year to year. Annual fluctuations in canopy species composition are thought to be the result of a complex combination of physical, chemical, and biological factors (Foster and Schiel 1985). Water motion (Rosenthal et al. 1974), water temperature/nutrients (Craig Barilotti pers. comm.), light intensity (Luning 1981), and available habitat, and exposure (Foster and Schiel 1985) have all been associated with kelp canopy health and development. In addition, warm water temperature anomalies, especially those associated with the "El Nino Southern Oscillation" (ENSO), have been known to dramatically reduce the abundance, diversity and stability of the near-shore kelp forest community (Tegner and Dayton 1991). In the latter months of 1997 and early 1998, the west coast of North America was again influenced by a significant ENSO countercurrent. It lasted several months, and raised surface sea temperatures by as much as eight degrees Fahrenheit in southern California and five degrees off the Washington coast (NOAA 1998). Aerial imagery obtained in the summer of 1998 revealed that the substantial southern California near shore *Macrocystis pyrifera* kelp canopy resource had been largely eliminated south of Newport Beach, presumably by these elevated temperatures or by resultant invertebrate overgrazing. Little is known regarding the effects of the ENSO, or other sea temperature anomalies, on the *Nereocystis* kelp resource.

The relationships of these individual physical factors, and identification of those that may be "limiting" at any one time, have yet to be fully understood, and continue to be the subject of numerous ongoing research investigations. In addition, adjacent kelp forests that appear to be exposed to similar physical factors may frequently produce vastly different canopy species compositions, further revealing the complexity of this dynamic habitat.

Biological factors, including the impact of herbivorous grazers such as sea urchins, are also a major element determining the extent and diversity of the near shore kelp resource (Foster and Schiel 1985). In that regard, the effects of a resident sea otter

population on the central California kelp resource, and a better understanding of the role of the otter in structuring near shore ecology are the subject of ongoing research interest. Their predation on invertebrate kelp grazers, mainly sea urchins (Jameson 1986), has been shown to dramatically reduce the density of these species, and to increase kelp canopy extent in areas of significant otter abundance (Kivitek 1989). This increase in the kelp resource has been observed to have dramatic effects on the diversity and abundance of associated species, and the resulting near shore community structure (Estes and Palmisano 1974). This otter/urchin/kelp interrelationship has resulted in the sea otters designation as a "keystone predator". Kvitek (1998) supported this designation by showing that sea otter predation along the Washington outer coast has significantly reduced the numbers of sea urchins and the grazing pressure that they exert. It was concluded that in the presence of an established otter population, sea urchin grazing was not the dominant force structuring the near-shore community. Continued research will be necessary to determine the impact of this important marine mammal on the nearshore kelp forest community.

In addition to the natural effects of physical, chemical, and biological factors on the near-shore environment, occasional "man-caused" pollution events may have significant additional effects on species abundance and diversity (Foster and Schiel 1985). In 1991, the collision of two ships, approximately 22 miles WNW of Cape Flattery, Washington (Rogne *et al.* 1993), resulted in the release of an estimated 100,000 gallons of #2 diesel fuel into the marine environment. In addition, oil continued to be released at a rate of 500 gallons/per day during the subsequent weeks. The prevailing WNW winds and seas carried the fuel oil towards both Vancouver Island and the Cape Flattery area. During its time at sea the oil was weathered, and would eventually be observed as "tar balls" in both the kelp beds, and to a lesser extent on rocks and beaches from Neah Bay to Cape Alava. Ongoing clean-up operations continued for several months after the spill in an attempt to minimize damage to the marine environment. Questions were raised from this event regarding the long-term effects of petroleum pollution on these kelp canopy forming species, and the resultant vulnerability of the related marine community.

Macrocystis canopies have been observed to be largely unaffected by hydrocarbon pollution, presumably due to the temporary protection provided by plant produced mucus (Mitchell *et al.* 1970), and the physical location of the reproductive sporophylls near the basal holdfast. Pollution effects on *Nereocystis* canopies have only been recently investigated (Antrim *et al.* 1995). Surface stipe tissue bleaching and loss, as a result of hydrocarbon contact, was observed both by Antrim (1995), and during the field clean-up operation following the 1991 Washington oil spill. However, it is still unclear whether or not subsequent seasonal *Nereocystis* recruitment is affected by these polluting elements.

The dynamic and sometimes vulnerable nature of the coastal kelp resource, considering its importance as habitat and food for hundreds of related species, points out the need for systematic methods of accurately assessing its extent and vitality. Until 1989, the California state-wide coastal kelp resource had only been sporadically mapped and analyzed since an initial state-wide visual survey conducted in 1915 (Rigg

1915). Earlier ground based estimates of kelp canopy extent have given way to modern aerial surveys, which provide a cost effective and accurate methodology for the mapping and quantification of near shore kelp resources (Jamison 1971).

A substantial portion of this dynamic kelp resource habitat falls within the Monterey Bay National Marine Sanctuary (MBNMS), established in 1992 as the largest United States marine sanctuary. The management area includes 276 miles of the California coastal zone between Rocky Point (7 miles north of the Golden Gate Bridge) and Cambria Rock (San Luis Obispo County), and extends from the beach to approximately 30 miles offshore. Within this management zone, occupying 5,322 square miles, 26 species of marine mammals, 94 species of seabirds, 345 species of fish, 31 phyla of invertebrates and over 450 species of marine algae have been observed. The MBNMS administration has four major components and mandates: 1) enhance resource protection, through comprehensive and coordinated conservation and management tailored to the specific resources, 2) support, promote and coordinate scientific research on, and monitoring of, the site-specific marine resources to improve management decision-making in National Marine Sanctuaries, 3) enhance public awareness, understanding, and wise use of the marine environment through public interpretive and recreational programs, and 4) facilitate, to the extent compatible with the primary objective of resource protection, multiple uses of these marine areas not prohibited pursuant to other authorities.

In response to this conservation and management mandate, Ecoscan Resource Data was contracted in this study to establish a kelp resource inventory program within the sanctuary-wide coastal zone between Rocky Pt. and Pt Estero. A state-wide kelp resource inventory, utilizing similar methodology, was conducted in 1989 (Van Wagenen 1989) for the California Department of Fish and Game (CDF&G), Marine Resources Division, and again in 1999 (Van Wagenen 1999) for the Monterey Bay National Marine Sanctuary.

The primary objective of this inventory was the continuation of a coastal kelp resource mapping and monitoring program that would accurately reflect the current sanctuary-wide seasonal maximum kelp resource extent. The methodology utilized was designed to not only allow a systematic, accurate analysis of multi-year data from current and future inventories, but to also allow meaningful comparisons with historic surveys as well.

Data acquisition was accomplished utilizing cost-effective medium format (70 mm) vertical aerial infrared photography. Data processing included the mapping of the imaged kelp canopies onto a consistent baseline map series, followed by a computer measurement of kelp canopy extent. Data analysis for short term trends in kelp canopy extent was accomplished by statistically comparing indices from the current inventory with those of the previous systematic study conducted in 1999. Mapping products from both surveys, at several scales, were included to graphically depict the spatial extent of this important resource.

Methods and Results

The methodology utilized in this kelp resource inventory, to document the extent of the kelp resource within the MBNMS, was divided into four phases:

- 1) Kelp canopy aerial photography,
- 2) Qualitative kelp bed canopy mapping,
- 3) Quantitative kelp bed canopy/planimeter area and density analysis (2000), and
- 4) Quantitative comparison of 1999 and 2000 kelp resource extent within the Monterey Bay National Marine Sanctuary.

The methods utilized in this current survey were similar to those used in the 1989 and 1999 inventories, to ensure data compatibility and comparability with these and other subsequent studies. Although the defined scope of this study was limited to the measurement of current resource abundance, specific comparisons were made with the last previous systematic analysis (1999), to document short-term changes in kelp canopy extent.

1) Kelp Canopy Aerial Photography

The methodology related to obtaining high-quality imagery of the fully developed 2000 California coastal kelp resource was divided into two sections: 1) survey timing, imaging, and logistic considerations, and 2) photography of the 2000 kelp resource.

1) Survey Timing, Imaging, and Logistic Considerations

The seasonal timing, photographic scale, and flight parameters of this aerial survey were established, as in previous surveys, to systematically obtain imagery that best represented the maximum extent of the current kelp resource. Acceptable "survey windows" were chosen for the aerial over-flights in response to several biological (seasonal timing of maximum canopy development), physical (tidal level, weather and sea state) and logistic factors (length of survey range).

Seasonal timing of maximum kelp canopy development was the major biological factor involved in scheduling this resource survey, and established the criteria around which all other logistic decisions were made. Within California, it has been observed, that the maximum extent of canopy forming kelp species occurs in August through October, with maturity of the *Nereocystis* canopy determining the beginning of this "biological window", and early season storms determining the end.

Within this three month period, several acceptable "tidal windows" were selected (utilizing NOAA tide tables for Monterey and San Simeon) that would allow the aerial imagery to be obtained at tidal levels of less than +1.0' MLLW. Once the tidal windows were established, the actual survey was conducted during the first window that had acceptable associated environmental conditions. These conditions included adequate ceiling and visibility (>10,000' MSL and five miles), surface winds less than ten knots, sea/swell less than five feet, and a sun angle of greater than 30 degrees from vertical.

In California, changeable weather (especially coastal fog, high winds and sea state) can be a major limiting factor on survey timing, and can frequently reduce the number of acceptable survey days in a given season to less than twenty. During the previous (1999) survey, the aerial imagery was obtained within these optimum biological, tidal, and environmental windows, thereby allowing meaningful comparisons of seasonal kelp resource areal extent.

The aircraft altitude (9,500' MSL) and photographic scale (1"=3,217') used for these surveys was selected to provide a good balance between resource resolution and rendition on the imagery, the selected base-mapping scale (1:24,000), and the overall length of the survey area (276 miles). At this altitude and photographic scale, the entire survey range (Cambria to Rocky Point) could be accurately recorded, under optimum conditions, during two low-tidal periods. Considering the changeable nature of California coastal weather; this methodology allowed the maximum utilization of the few optimum survey dates. With regards to resource resolution on the imagery; ground truth measurements have indicated that the smallest kelp "dots" on the 1:24,000 scale maps (approximately the size of a text "period" from this document), represent as few as six surface stipes from a single *Macrocystis* kelp plant.

The film used on this survey was 70 mm Kodak color infrared - type 2443, the accepted standard for use in documenting the areal extent of marine surface vegetation. Its ability to increase the contrast between kelp and the surrounding water, without sacrificing resolution, made it ideal for resource surveys of this type. Despite this ability, infrared film does have limitations regarding its utility in recording sub-surface coastal kelp canopies. Due to its poor water penetration properties of approximately two feet (Helgeson 1970); this film will not record kelp stipes that are significantly pulled below the surface due to high winds and seas, high tides, and tidal currents. This especially affects sparse *Nereocystis* canopies, which can be completely submerged by the above factors (especially tidal currents), and not recorded on the imagery. Careful attention to survey timing that corresponded with acceptable winds, seas, and the "time of the low tide" at each coastal location, was necessary to insure accurate canopy rendition on the imagery.

2) Photography of the 2000 Kelp Resource

When the biological, tidal, imaging, and logistic factors were considered together, three possible "optimum survey windows" were established for the 2000 kelp resource inventory: 1) August 1 - 5, 2) August 10 - 19, and 3) August 27 - 31, 2000.

Aerial photography of the 2000 kelp resource was accomplished on August 10 and August 30, 2000 during the second and third optimum survey windows. Calm winds, low seas, and mostly clear skies were present throughout the survey range on both dates, with the exception of patchy mid-level clouds (4,000' MSL) from Pt. Sur south to Pt. Piedras Blancas on August 30. A summary of associated environmental conditions, in addition to visual observations taken during the survey were presented in figures 1.1 and 1.2.

Continuous, sequential, vertical photographs (20%-30% overlap) were taken from 9,500' MSL (75mm lens) of the coastal zone between Rocky Point and Seacliff Beach on August 10, and from Seaside to Point Estero on August 30. Approximately 20% shoreline was included on each image to facilitate accurate projection onto the base-line maps. Larger canopies, that were not fully recorded on the initial "in-shore" photographic transect, were referenced on parallel "off-shore" flight lines. Each new transect was "side-lapped" by 30%-40% with those in-shore, to facilitate the accurate mapping of these off-shore canopies.

The imagery from each of the survey dates was processed normally, judged of excellent quality, and allowed the complete and subsequent mapping of the coastal kelp canopies within the study range. This indexed imagery was presented as: "California Coastal Kelp Resources – Monterey Bay National Marine Sanctuary - Summer 2000 -Aerial Survey Imagery" – Binder 1/1 "Bollinas Lagoon to Pt. Estero".

2) Qualitative Kelp Bed Canopy Mapping

Kelp bed mapping was accomplished in two phases: A) base-line map preparation, and B) kelp bed canopy area mapping and indexing.

A) Base-line Map Preparation

The base-line maps for this coastal kelp survey were originally designed for the 1989 inventory, and subsequently used again in this effort. This base-map series presents an accurate and continuous depiction of the California state coastal zone from the Oregon to the Mexican borders, including southern California offshore islands, and allowed the systematic mapping of the sanctuary-wide resource.

Eighty-three contiguous base-line maps (24"x36", scale 1:24,000) were made of the California coastal zone using USGS 7 1/2' quadrangle maps (scale 1:24,000) as a reference. These maps offered extensive shoreline detail, high accuracy, and continuous coastal coverage for the entire state. Each of the "quad" maps was copied on a calibrated photocopier (Sharp "8400"). The contiguous "shoreline" portions of each of the map copies were then assembled together, and became the land reference on each of the base maps. All standard detail from these USGS maps was preserved, including prominent shoreline features, offshore rocks, rivers, beaches, rocky intertidal habitat, towns, harbors, and topographic relief. In addition, the CDF&G kelp bed numbering system, which divides the state-wide kelp resource into discrete beds based on bearings from key geographic points, was also included.

The coastal zone, within the MBNMS, from Rocky Point to Cambria Rock, was located on maps 27 – 44 within this 83 map set. These maps were indexed by map number (table 1), and map name (table 2), and CDF&G numbered kelp beds present on each map page were also included. To aid in orientation and facilitate the "field use" of the maps, prominent geographic features were listed alphabetically in tabular form (table 3), with cross-references to the map name and number where they were found.

B) Kelp Bed Canopy Area Mapping and Indexing

All color infrared slides from the survey were projected onto the base-line maps, and after aligning common shoreline features from each media, individual kelp plants and kelp canopies (see glossary) were hand transferred. The transfer process specifically involved: 1) the visual analysis of the extent of kelp represented on each slide by reference to color and surface appearance, 2) the identification of the "usable" portion of the image that was largely distortion-free (center three-fourths), 3) positioning this "usable" portion of the projected image in its proper location on the base-map, with regard to both shore-line features and kelp from other overlapping imagery, and 4) the black shading of all visible kelp, both developed canopies and individual plants. These black-shaded areas represented the areal extent of the actual kelp plants composing the surface canopy, and areas within the perimeter of the canopy that did not contain kelp were left un-shaded. When fully rendered from the survey imagery, each mapped canopy closely resembled the appearance of the actual surface canopy when viewed from above.

These mapped canopies represented the qualitative kelp bed canopy area (see glossary) occupied within the survey range, and were presented in Section 4 - "Kelp Bed Canopy Area Maps: 27-44" – August 2000 (24"x36", 11"x17", and 8.5"x11"). Similar maps from the 1999 inventory were presented in Section 5 - "Kelp Bed Canopy Area Maps: 27-44" - October 1999 (8.5"x11") for comparative purposes.

3) **Quantitative Kelp Canopy/Planimeter Areas and Relative Density Analysis**

The quantitative analysis of the sanctuary-wide kelp resource abundance within the MBNMS was divided into three sections: a) analysis of the 2000 MBNMS sanctuary-wide coastal kelp resource, by CDF&G kelp bed number, and b) comparison of the 2000 kelp resource extent with that measured during the 1999 inventory. Observed large-scale changes in resource abundance were presented in the "Data Summary/Principle Findings" section.

A) Analysis of the 2000 MBNMS Sanctuary-wide Coastal Kelp Resource

Quantitative kelp bed canopy and planimeter areas (see glossary) were accurately determined from the maps using computer image processing techniques. Each map page was scanned full scale at 100 dots/inch (dpi) using a "Microtek" 9600 XL flat-bed image scanner. Area values were determined by screen "pixel counting", utilizing "Global Lab Image" (V3.1) image processing software (Data Translation).

Kelp bed canopy/planimeter areas and values for the relative density index (see glossary) were tabulated by CDF&G kelp bed number, presented in table 4, and plotted in figure 2.

Similar indices from the 1999 inventory were presented, by CDF&G kelp bed number, in table 5, and plotted in figure 3.

B) Comparisons of the 1999 and 2000 MBNMS Coastal Kelp Resource

Kelp bed canopy/planimeter areas and values for the relative density index, from the 1999 inventory in addition to similar values from the current inventory were presented in Table 6 and plotted in figure 4

In order to evaluate the significance of observed changes in resource extent between the two surveys, a t-test ("paired two sample for means") was applied to the sequential data sets from tables 6. This test evaluated whether a samples' means were distinct, and did not assume equal population variance (Sokal and Rohlf, 1981). This test was judged appropriate, since there was a natural pairing of measurements making up each distinct value for canopy/planimeter area and RDI. Each data pair were analyzed at the 95% confidence level ($p = .05$), and the results of the tests were summarized in the "data summary/principle findings" section.

All spreadsheet data from tables 1-6 are provided in "Excel 95/97" ("XLS" - Microsoft Inc.) file format. The data file, MBNMSK00.XLS, was included on two 3.5" floppy disks, and presented in each of the data binders in Section 6 – Electronic Data.

Data Summary

This data summary will focus mainly on a "large scale" assessment of the 2000 MBNMS coastal kelp resource, and changes observed since the 1999 inventory. As a result of this data tabulation method, though, additional "small scale" changes in kelp resource extent may become apparent, as further research is conducted. Investigators are encouraged to use these data in that regard. Care must be taken, though, in interpreting these observed changes, since only two data sets were involved, spanning one year. At best, these data represent short-term changes only and don't necessarily reflect long-term trends in kelp resource extent and distribution.

In addition, it is intended in future surveys, to substantially expand the scope of this analysis to include numerous areas of research interest, and to track the sanctuary-wide kelp resource, by kelp species, to better understand the inter-specific interactions and environmental structuring elements of the MBNMS kelp resource.

Principle Findings

The principle findings from the 2000 Monterey Bay National Marine Sanctuary kelp resource inventory were summarized, by CDF&G kelp bed numbers, as follows:

- 1) 2000 kelp resource extent,
- 2) 1999 kelp resource extent, and
- 3) Comparisons of the 1999 and 2000 sanctuary-wide coastal kelp resource.

1) Summary of the 2000 Sanctuary-wide Kelp Resource Extent

The total 2000 surface kelp canopy resource, within the MBNMS (CDF&G kelp beds 208-225), occupied canopy/planimeter areas of 17.051 sq. mi. and 24.663 sq. mi., respectively. The relative density index was measured at .71.

2) Summary of the 1999 Sanctuary-wide Kelp Resource Extent

The total 1999 surface kelp canopy resource, within the MBNMS (CDF&G kelp beds 208-225), occupied canopy/planimeter areas of 14.053 sq. mi. and 22.358 sq. mi., respectively. The relative density index was measured at .63.

3) Summary Comparisons of the 1999-2000 Sanctuary-wide Kelp Resource

The total sanctuary-wide kelp resource canopy area significantly increased ($p=.05$) from 14.053 sq. mi. to 17.451 sq. mi., which represented a 24% increase in surface canopy from that measured in 1999. The 1999-2000 total kelp bed planimeter area also significantly increased from 22.358 to 24.663 sq. mi., which represented a 10% increase in planimeter extent. The relative density index also significantly increased from .63 (1999) to .71 (2000).

Although virtually all canopies within the survey range showed an increase in surface extent, the greatest increase was observed within Monterey Bay itself (CDF&G canopies 222, 221 and 220). Increases in canopy areas of 120%, 206% and 66%, respectively, were noted. In addition, increases in planimeter areas of 59%, 33%, and 43%, respectively, were also observed within these canopies.

The only canopy to experience a substantial loss in surface extent was canopy 208 (Cambria to Pt. Estero), which was reduced by 24% in canopy area and 14% in planimeter area.

Discussion

This scope of this inventory was established to provide a current, accurate measurement of the coastal kelp resource located within the Monterey Bay National Marine Sanctuary. In addition, future inventories may expand on this analysis in an effort to promote a better understanding of the seasonal dynamics of this important resource. In this regard, discussion will be limited to comparative methodology and sources of error that may affect the accuracy of this current inventory, and its subsequent utility for multi-year comparative purposes.

The data acquisition methodology utilized in this survey was established for the 1989 California state-wide inventory, and, with limited exception, has remained consistent in this current effort. The only change in data acquisition parameters has involved changing the camera/film format from 35mm in 1989 to 70mm in 1999, and the flight altitude from 7,500' MSL in 1989 to 9,500' MSL in 1999. The larger film format utilized in 1999 allowed this increase in altitude without sacrificing resolution on the imagery,

and permitted the kelp canopies to be more quickly imaged on the few optimum survey days.

Imagery for the 2000 inventory was also collected from 9,500' MSL using a 75mm lens (scale 1:3,217), except within the range from Pt. Sur to Pt. Piedras Blancas. Within this range a mid-level cloud layer at 4,000' MSL forced the imagery to be collected from 3,500' MSL, using a 35mm lens (scale 1:2,540). Although a lower altitude was required for imagery acquisition, optimum associated environmental conditions were present. The slight difference in photographic scale was judged insignificant with regard to the utility of the imagery for mapping the current resource and for multi-year comparative purposes.

An additional difference in methodology involved the timing of imagery acquisition for the 1999 and 2000 inventories. Persistent coastal fog during August and September 1999 delayed imagery acquisition until early October and may have underrepresented the kelp located in Monterey Bay proper (canopies 222, 221, and 220). In recent years, these surface kelp canopies have been observed to reach their summer maximum in June through August and begin to lose surface extent through canopy senescence due to elevated temperatures and reduced nutrients present in September and October each year. The outer coast has not been observed to experience this early loss of surface canopy, presumably due to increased nutrient availability in the late summer months. Favorable weather permitted all of the imagery for the 2000 inventory to be completed within the month of August, and likely better represented the maximum summer canopy present within the Monterey Bay proper.

With limited noted exceptions, all other data processing, mapping and analysis methodology, in addition to computation, tabulation, and presentation formats have remained consistent in this 2000 inventory, when compared to the previous 1999 effort. This should allow valid future quantitative comparisons of trends in kelp resource abundance as this inventory is continued.

Conclusion

This coastal kelp resource inventory was established to be a tool in the hands of researchers, and agency management professionals, leading toward a better understanding of the marine environment within the Monterey Bay National Marine Sanctuary.

In response to the stated resource monitoring and research mandate of the sanctuary program; this survey provided important data regarding the status of current kelp canopy abundance, in addition to comparisons with the 1999 inventory. We acknowledge the Monterey Bay National Marine Sanctuary for their encouragement and support of this work, and for their commitment to a better understanding of the complex processes structuring the nearshore marine environment.

Glossary

Kelp Bed Canopy - An aggregation of surface kelp plants in close proximity to each other which produced a consistent infrared return on the imagery, such that individual plants were indistinguishable when projected at mapping scale (1:24,000)

Kelp Bed Qualitative Canopy Area - The geographic (spatial) extent of individual surface kelp plants and canopies, as fully rendered from the original imagery. Each visible individual kelp plant and canopy was hand transferred to the "canopy area" maps, and represented by black-shading wherever present. Areas within the perimeter of the canopy that did not contain kelp were left un-shaded. This index depicted the actual appearance of the surface kelp canopy, as viewed on the original imagery.

Kelp Bed Quantitative Canopy Area - The numeric extent (sq. mi.) of individual surface kelp plants and canopies. Each qualitative canopy area map was scanned into the image processing system at full scale (1:24,000), and subsequent screen "pixel counts" conducted. All "black-shaded" pixels that represented actual kelp at the surface were counted, individual pixel area determined, and a quantitative kelp canopy area established. This index represented, numerically, the actual extent of the surface kelp canopy, as mapped from the original imagery.

Kelp Bed Qualitative Planimeter Area - The geographic (spatial) extent of the surface kelp canopy contained within its own perimeter, assuming continuous kelp coverage within. Since the surface kelp resource was composed of individual plants and established canopies; this measurement systematically defined the perimeter and subsequent enclosed area of this plant assemblage. This value depicted kelp canopy areal extent in slightly different terms than "canopy area", as previously defined, and served three purposes in this analysis: 1) it allowed comparisons of current and historic estimates of kelp resource abundance, which utilized similar "perimeter" estimation methods, 2) it allowed an understanding of the sea surface area that was actually occupied or influenced by the kelp canopy, and 3) it allowed a measurement of kelp canopy density (see "kelp bed relative density index").

Qualitative planimeter area, by kelp bed number, was established by computer enhancement of each scanned "canopy area" map. This methodology systematically established perimeter polygons around each kelp canopy, and included all kelp plants inside the polygons that were within 50 meters of each other, giving each plant a 25 meter "radius of association" (1 mm at the 1:24,000 mapping scale). Within the analysis software ("Global Lab Image"-V3.1-Data Translation), individual kelp plants and canopies within were "dilated" (expanded) with a "5x5" pixel "structuring element", thereby adding a 25 meter radius of kelp to each existing kelp pixel. Individual kelp plants within 50 meters of each other became part of the same perimeter, while plants greater than 50 meters apart retained discrete perimeters. Within established canopies, this transform had the effect of defining the canopy perimeter 25 meters beyond that visually apparent on the "canopy area" maps, as well as filling in the all of the "holes" in kelp coverage within the canopy. This computer synthesized value is spatially similar to that obtained by using a hand planimeter to determine kelp canopy

areal extent, and hence the name. Many environmental surveys have used planimeter areas to describe resource abundance, since prior to computers, this was all that was available. In addition, by the nature of the process, area statistics from other hand digitized kelp resource maps (for data entry into a geographic information system; see definition), will closely approximate the quantitative planimeter area (see definition), thereby allowing comparisons. This index is always larger than the kelp "canopy area", which is a depiction and measurement of the sea surface area actually occupied by visible kelp plants.

In addition to allowing comparisons with both historic (planimeter derived), and computer (digitizer derived) data, planimeter area measurements more accurately depict the extent, or sea surface area occupied, by kelp canopy species that have more irregular distributions (dense canopies in some areas and sparse areas containing individual plants in others). *Nereocystis* sp. canopies are frequently observed with this growth pattern, and their prominence underrepresented by a strict "canopy area" analysis only.

Kelp Bed Quantitative Planimeter Area - The numeric extent (sq. mi.) of the qualitative planimeter area (see glossary). Each quantitative planimeter area, by CDF&G canopy number was scanned into the image processing program, and a screen "pixel count" conducted. All pixels within the individual perimeters were counted, individual pixel area determined, and a quantitative canopy planimeter area established.

Kelp Bed Relative Density Index (RDI) - The percentage of the planimeter area that actually contained surface kelp plants. This index was calculated by dividing the canopy area by the planimeter area and approximated the probability of encountering kelp at a random point within the canopy perimeter. This value approaches "1" for very dense canopies and "0" for very sparse canopies. The measurement is independent of canopy size, and a good indicator of changes in density over time. In considering the relationship between canopy area and planimeter area, several examples underscore this basic relationship, and subsequent multi-year trends.

Canopy Area (sq. mi.)	Planimeter Area (sq. mi.)	Relative Density (RDI)	Interpretation
1.0	2.0	.5	1.0 sq. mi. of kelp is contained within 2.0 sq. mi. of the sea surface that it occupies (prob. of encountering kelp within perimeter = .5)
.5	2.0	.25	.5 sq. mi. of kelp is contained within 2.0 sq. mi. of the sea surface that it occupies (prob. of encountering kelp within perimeter = .25)
Can. Chg.	Plan. Chg.	Den. Ch	Interpretation - Multi-Year Trends
1.0 to 1.0	2.0 to 2.0	.5 to .5	Kelp resource area (canopy area), spatial extent (plan. area), and density (RDI) stable over time
1.0 to 1.5	2.0 to 2.0	.5 to .75	Increased resource area within similar spatial extent at inc. dens.
1.0 to 2.0	2.0 to 4.0	.5 to .5	Inc. resource area and spatial extent at similar densities
1.0 to 2.0	2.0 to 3.0	.5 to .66	Inc. resource area and spatial extent at increasing densities

1.0 to 1.5	2.0 to 4.0	.5 to .38	Inc. resource area and spatial extent at decreasing densities
1.0 to .5	2.0 to 2.0	.5 to .25	Dec. resource area within similar spatial extent at dec. density
1.0 to .5	2.0 to 1.0	.5 to .5	Dec. resource area and spatial extent at similar densities
1.0 to .5	2.0 to 1.5	.5 to .33	Dec. resource area and spatial extent at decreasing densities
1.0 to .5	2.0 to 3.0	.5 to .16	Dec. resource area within inc. spatial extent at dec. densities

Geographic Information System (GIS) - A computer software platform designed to facilitate the assembly and analysis of diverse data sets pertaining to specific geographic areas using spatial locations of the data as the basis for the information system

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**CALIFORNIA COASTAL
KELP RESOURCES**

Bolinas Lagoon
to
Point Estero

Section 2

Tables

August 2000

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Table 1
 California Coastal Kelp Resources - Summer 2000
 Monterey Bay National Marine Sanctuary
Kelp Resource Map Index
 - By Map Number

MAP NUMBER	MAP NAME	CDF&G KELP BED NUMBERS
C-27	Bolinas	
C-28	San Francisco	
C-29	Montara	225
C-30	Half Moon Bay	225
C-31	Pigeon Point	224, 225
C-32	Ano Nuevo	223, 224
C-33	Davenport	222, 223
C-34	Santa Cruz	221, 222
C-35	Moss Landing	221
C-36	Marina	221
C-37	Monterey	217, 218, 219, 220, 221
C-38	Pt. Sur	216, 217
C-39	Pfeiffer Pt.	214, 215, 216
C-40	Lopez Pt.	213, 214
C-41	Cape San Martin	212, 213
C-42	Ragged Pt.	211, 212
C-43	Pt. Piedras Blancas	209, 210, 211
C-44	Cambria	208, 209

Table 2
 - California Coastal Kelp Resources - Summer 2000
 Monterey Bay National Marine Sanctuary
Kelp Resource Map Index
 - By Map Name

MAP NAME	MAP NUMBER	CDF&G KELP BED NUMBERS
Ano Nuevo	C-32	223, 224
Bolinas	C-27	
Cambria	C-44	208, 209
Cape San Martin	C-41	212, 213
Davenport	C-33	222, 223
Half Moon Bay	C-30	225
Lopez Pt.	C-40	213, 214
Marina	C-36	221
Montara	C-29	225
Monterey	C-37	217, 218, 219, 220, 221
Moss Landing	C-35	221
Pfeiffer Pt.	C-39	214, 215, 216
Pigeon Point	C-31	224, 225
Pt. Piedras Blancas	C-43	209, 210, 211
Pt. Sur	C-38	216, 217
Ragged Pt.	C-42	211, 212
San Francisco	C-28	
Santa Cruz	C-34	221, 222

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
17 Mile Dr.	Monterey	C-37
Agate Beach County Park	Bolinas	C-27
Alder Creek	Ragged Pt.	C-42
Anderson Creek	Lopez Pt.	C-40
Anderson Landing	Lopez Pt.	C-40
Ano Nuevo Bay	Ano Nuevo	C-32
Ano Nuevo Island	Ano Nuevo	C-32
Aptos (city)	Santa Cruz	C-34
Aptos Creek	Santa Cruz	C-34
Arroyo de la Cruz	Pt. Piedras Blancas	C-43
Arroyo de los Chinos	Ragged Pt.	C-42
Arroyo del Oso	Pt. Piedras Blancas	C-43
Arroyo del Padre	Pt. Piedras Blancas	C-43
Bean Hollow Beach	Pigeon Pt.	C-31
Bennett Slough	Moss Landing	C-35
Big Creek	Lopez Pt.	C-40
Big Lagoon	Bolinas	C-27
Bird Island	San Francisco	C-28
Bird Island	Monterey	C-37
Bird Rock	Monterey	C-37
Bixby Landing	Pt. Sur	C-38
Bolinas (city)	Bolinas	C-27
Bolinas Bay	Bolinas	C-27
Bolinas Lagoon	Bolinas	C-27
Bolinas Pt.	Bolinas	C-27
Bolsa Pt.	Pigeon Pt.	C-31
Bonita Cove	San Francisco	C-28
Broken Bridge Creek	Pt. Piedras Blancas	C-43
Burns Creek	Lopez Pt.	C-40
Butano Creek	Pigeon Pt.	C-31
Cambria (town)	Cambria	C-44
Cambria Radar Station (former)	Cambria	C-44
Cannery Row	Monterey	C-37
Cape San Martin	Cape San Martin	C-41
Capitola (city)	Santa Cruz	C-34
Capitola State Beach	Santa Cruz	C-34

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Camel (city)	Monterey	C-37
Camel Bay	Monterey	C-37
Camel Highlands	Monterey	C-37
Camel Pt.	Monterey	C-37
Camel River	Monterey	C-37
Camel Valley	Monterey	C-37
Castro Canyon	Pfeiffer Pt.	C-39
Castroville (town)	Moss Landing	C-35
Cement Plant	Davenport	C-33
China Bluff	Ragged Pt.	C-42
Cooper Pt.	Pfeiffer Pt.	C-39
Coral de Tierra	Half Moon Bay	C-30
Corcoran lagoon	Santa Cruz	C-34
Cowell Beach	Santa Cruz	C-34
CSU Monterey Bay	Marina	C-36
Cypress Pt.	Monterey	C-37
Davenport (town)	Davenport	C-33
Davenport Landing	Davenport	C-33
De La Cruz Rock	Pt. Piedras Blancas	C-43
Del Monte Lake	Marina	C-36
Devils Canyon	Lopez Pt.	C-40
Devils Slide	Montara	C-29
Dolan Canyon	Lopez Pt.	C-40
Dolan Creel	Lopez Pt.	C-40
Dolan Rock	Lopez Pt.	C-40
Duxberry Pt.	Bolinas	C-27
Duxberry Reef	Bolinas	C-27
Edgemar (town)	Montara	C-29
Eel Rock	Half Moon Bay	C-30
El Granada Beach	Half Moon Bay	C-30
El Jarro Pt.	Davenport	C-33
Elkhorn Slough	Moss Landing	C-35
Fan Shell Beach	Monterey	C-37
Fort Barry Military Res.	San Francisco	C-28
Fort Old Military Res. (former)	Marina	C-36
Frank Valley	Bolinas	C-27

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Franklin Pt.	Ano Nuevo	C-32
Gamboa Pt.	Lopez Pt.	C-40
Garrapata Creek	Pt. Sur	C-38
Golden Gate Bridge	San Francisco	C-28
Golden Gate Park	San Francisco	C-28
Gorda (town)	Cape San Martin	C-41
Gordola (town)	Davenport	C-33
Green Oaks Creek	Ano Nuevo	C-32
Greyhound Rock	Ano Nuevo	C-32
Grimes Canyon	Pfeiffer Pt.	C-39
Grimes Pt.	Pfeiffer Pt.	C-39
Gulf Rock	Bolinas	C-27
Half Moon Bay (city)	Half Moon Bay	C-30
Half Moon bay Airport	Half Moon Bay	C-30
Hare Canyon	Cape San Martin	C-41
Harlan Rock	Cape San Martin	C-41
Harlech Castle Rock	Pt. Piedras Blancas	C-43
Hearst Airport	Pt. Piedras Blancas	C-43
Hearst Castle State Historical Mon.	Pt. Piedras Blancas	C-43
Hearst Ranch	Pt. Piedras Blancas	C-43
Hopkins Marine Station	Monterey	C-37
Hot Springs Canyon	Lopez Pt.	C-40
Hunter Liggett Military Res.	Ragged Pt.	C-42
Hurricane Pt.	Pt. Sur	C-38
Indian Head Beach	Marina	C-36
Kasler Pt.	Pt. Sur	C-38
Kent Island	Bolinas	C-27
Kings Rock	Half Moon Bay	C-30
Kirk Creek	Cape San Martin	C-41
La Selva Beach (town)	Santa Cruz	C-34
Laffler Canyon	Pfeiffer Pt.	C-39
Laguna Creek	Davenport	C-33
Laguna Salada	Montara	C-29
Lake Lucerne	Pigeon Pt.	C-31
Lake Merced	San Francisco	C-28
Lands End	San Francisco	C-28

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Leffingwell Creek	Cambria	C-44
Lime Creek	Lopez Pt.	C-40
Limekiln Creek	Cape San Martin	C-41
Little Pico Creek	Pt. Piedras Blancas	C-43
Little Sur River	Pt. Sur	C-38
Live Oak (town)	Santa Cruz	C-34
Lobos Rocks	Pt. Sur	C-38
Lopez Pt.	Lopez Pt.	C-40
Lopez Rock	Lopez Pt.	C-40
Lovers Pt.	Monterey	C-37
Lucia (town)	Cape San Martin	C-41
Manresa Beach	Santa Cruz	C-34
Manresa Beach	Moss Landing	C-35
Marina (town)	Marina	C-36
Marina State Park	Marina	C-36
Martins Beach	Half Moon Bay	C-30
McClusky Slough	Moss Landing	C-35
McWay Creek	Lopez Pt.	C-40
McWay Slide	Lopez Pt.	C-40
Mile Rock	San Francisco	C-28
Mill Creek	Cape San Martin	C-41
Miramar	Half Moon Bay	C-30
Miramar Beach	Half Moon Bay	C-30
Miramontes Pt.	Half Moon Bay	C-30
Montara (town)	Montara	C-29
Montara Beach	Montara	C-29
Monterey (city)	Monterey	C-37
Monterey Bay Academy	Moss Landing	C-35
Monterey Bay Aquarium	Monterey	C-37
Monterey Coast Guard Station	Monterey	C-37
Monterey County Fairgrounds	Marina	C-36
Monterey Municipal Airport	Marina	C-36
Moore Creek	Davenport	C-33
Moran Lake	Santa Cruz	C-34
Mori Point	Montara	C-29
Moss Beach (town)	Montara	C-29

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
 - By Location

LOCATION	MAP NAME	MAP NUMBER
Moss Landing (town)	Moss Landing	C-35
Moss Landing Harbor	Moss Landing	C-35
Mt. Tamalpias State Park	Bolinas	C-27
Muir Beach	Bolinas	C-27
Mussel Rock	Montara	C-29
Mussel Rock	Pigeon Pt.	C-31
Natural Bridges Beach State Park	Davenport	C-33
Needle Rock Pt.	Davenport	C-33
New Brighton State Beach	Santa Cruz	C-34
Oak Knoll Creek	Pt. Piedras Blancas	C-43
Olympic Golf Club	San Francisco	C-28
Opal Cliffs Beach	Santa Cruz	C-34
Otter Pt.	Monterey	C-37
Pacific Grove (city)	Monterey	C-37
Pacific Manor (town)	Montara	C-29
Pajaro Dunes Development	Moss Landing	C-35
Pajaro River	Moss Landing	C-35
Palm Beach	Moss Landing	C-35
Palo Colorado Canyon Creek	Pt. Sur	C-38
Partington Creek	Pfeiffer Pt.	C-39
Partington Pt.	Pfeiffer Pt.	C-39
Pebble Beach Golf Course	Monterey	C-37
Pelican Rock	Ano Nuevo	C-32
Pescadero Beach	Pigeon Pt.	C-31
Pescadero Pt.	Pigeon Pt.	C-31
Pfeiffer Big Sur State Park	Pfeiffer Pt.	C-39
Pfeiffer Pt.	Pfeiffer Pt.	C-39
Pfeiffer Rock	Pfeiffer Pt.	C-39
Pfeiffer Rock	Pfeiffer Pt.	C-39
PG&E Moss Landing Power Plant	Moss Landing	C-35
Pico Creek	Pt. Piedras Blancas	C-43
Pico Rock	Pt. Piedras Blancas	C-43
Pigeon Pt.	Pigeon Pt.	C-31
Pillar Pt.	Half Moon Bay	C-30
Pillar Pt. Harbor	Half Moon Bay	C-30
Pirates Cove	Bolinas	C-27

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Plaskett (town)	Cape San Martin	C-41
Plaskett Creek	Cape San Martin	C-41
Plaskett Rock	Cape San Martin	C-41
Pomponio Beach	Pigeon Pt.	C-31
Prewitt Creek	Cape San Martin	C-41
Princeton (town)	Half Moon Bay	C-30
Pt. Ano Nuevo	Ano Nuevo	C-32
Pt. Bonita	San Francisco	C-28
Pt. Cabrillo	Monterey	C-37
Pt. Estero	Cambria	C-44
Pt. Joe	Monterey	C-37
Pt. Lobos	San Francisco	C-28
Pt. Lobos State Reserve	Monterey	C-37
Pt. Montara	Montara	C-29
Pt. Piedras Blancas	Pt. Piedras Blancas	C-43
Pt. Piedras Blancas Lighthouse	Pt. Piedras Blancas	C-43
Pt. Pinos	Monterey	C-37
Pt. San Pedro	Montara	C-29
Pt. Santa Cruz	Santa Cruz	C-34
Pt. Sierra Nevada	Ragged Pt.	C-42
Pt. Sur	Pt. Sur	C-38
Pt. Sur Lighthouse	Pt. Sur	C-38
Purisima Creek	Half Moon Bay	C-30
Ragged Pt.	Ragged Pt.	C-42
Rat Creek	Lopez Pt.	C-40
Redondo beach	Half Moon Bay	C-30
Redwood Gulch	Ragged Pt.	C-42
Rio Del Mar (town)	Santa Cruz	C-34
Rockland Landing	Cape San Martin	C-41
Rocky Point	Bolinas	C-27
Rocky Pt.	Pt. Sur	C-38
Rodeo Cove	San Francisco	C-28
Salinas National Wildlife Refuge	Marina	C-36
Salinas River	Moss Landing	C-35
Salinas River	Marina	C-36
Salmon Cone Mountain	Ragged Pt.	C-42

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Salmon Creek	Ragged Pt.	C-42
San Carpoforo Creek	Ragged Pt.	C-42
San Francisco (city)	San Francisco	C-28
San Francisco Bay	San Francisco	C-28
San Gregorio Creek	Pigeon Pt.	C-31
San Lorenzo River	Santa Cruz	C-34
San Mateo Coast State Beaches	Half Moon Bay	C-30
San Pedro Rock	Montara	C-29
San Pedro Valley (town)	Montara	C-29
San Simeon (town)	Pt. Piedras Blancas	C-43
San Simeon Bay	Pt. Piedras Blancas	C-43
San Simeon Beach State Park	Cambria	C-44
San Simeon Pt.	Pt. Piedras Blancas	C-43
San Vicente Creek	Montara	C-29
Sand Beach	Pigeon Pt.	C-31
Sand City (town)	Marina	C-36
Sand Hill Bluff	Davenport	C-33
Santa Cruz (city)	Santa Cruz	C-34
Santa Cruz Harbor	Santa Cruz	C-34
Santa Cruz Municipal Pier	Santa Cruz	C-34
Schwans Lagoon	Santa Cruz	C-34
Scott Creek	Ano Nuevo	C-32
Seacliff State Beach	Santa Cruz	C-34
Seal Cove	Half Moon Bay	C-30
Seal Lion Rocks	Monterey	C-37
Seal Rock	Half Moon Bay	C-30
Seal Rock	Monterey	C-37
Seal Rocks	San Francisco	C-28
Seaside (town)	Marina	C-36
Sharp Park	Montara	C-29
Shelter Cove	Montara	C-29
Slate Rock	Lopez Pt.	C-40
Soberanes Pt.	Pt. Sur	C-38
Soda Spring Creek	Ragged Pt.	C-42
Soquel (city)	Santa Cruz	C-34
Soquel Creek	Santa Cruz	C-34

Table 3
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Geographic Features Index
- By Location

LOCATION	MAP NAME	MAP NUMBER
Soquel Pt.	Santa Cruz	C-34
South Cambria (town)	Cambria	C-44
South Fork Creek	Cape San Martin	C-41
Spanish Bay	Monterey	C-37
Spring Bridge Gulch	Pigeon Pt.	C-31
Square Black Rock	Lopez Pt.	C-40
Stillwater Cove	Monterey	C-37
Stinson Beach	Bolinas	C-27
Sunset Pt.	Monterey	C-37
Sunset State Beach	Moss Landing	C-35
Sycamore Canyon	Pfeiffer Pt.	C-39
Tennessee Pt.	Bolinas	C-27
Terrace Pt.	Davenport	C-33
Thornton Beach State Park	San Francisco	C-28
Torre Canyon	Pfeiffer Pt.	C-39
Tunitas Beach	Pigeon Pt.	C-31
Tunitas Creek	Pigeon Pt.	C-31
Twin Lakes Beach	Santa Cruz	C-34
Vanelcia Creek	Santa Cruz	C-34
Ventura Rocks	Pt. Sur	C-38
Vincente Creek	Lopez Pt.	C-40
Watsonville Slough	Moss Landing	C-35
Whitehouse Creek	Ano Nuevo	C-32
Wild Cattle Creek	Cape San Martin	C-41
Willow Creek	Cape San Martin	C-41
Woods Lagoon	Santa Cruz	C-34
Wreck Beach	Pfeiffer Pt.	C-39
Yankee Gulch	Pigeon Pt.	C-31
Yankee Pt.	Monterey	C-37
Zmudowski Beach State Park	Moss Landing	C-35

Table 4
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Kelp Bed Canopy/Planimeter Area/Relative Density Index
Summer 2000
 - By CDF Kelp Bed Number

CDF&G KELP BED NUMBER	Kelp Bed Canopy Area (sq. mi.)	Kelp Bed Planimeter Area (sq. mi.)	Relative Density Index (RDI)
225	0.002	0.024	0.11
224	0.019	0.083	0.22
223	0.094	0.361	0.26
222	0.583	1.060	0.55
221	0.423	0.630	0.67
220	1.262	1.669	0.76
219	1.296	1.494	0.87
218	0.405	0.534	0.76
217	2.120	2.777	0.76
216	2.217	2.647	0.84
215	0.614	0.891	0.69
214	1.811	2.246	0.81
213	1.355	2.037	0.67
212	0.678	0.985	0.69
211	1.249	1.858	0.67
210	1.243	1.902	0.65
209	0.895	1.562	0.57
208	1.187	1.903	0.62
	17.451	24.663	0.71

Table 5
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Kelp Bed Canopy/Planimeter Area/Relative Density Index
Summer 1999
 - By CDF Kelp Bed Number

CDF&G KELP BED NUMBER	Kelp Bed Canopy Area (sq. mi.)	Kelp Bed Planimeter Area (sq. mi.)	Relative Density Index (RDI)
225	0.000	0.000	0.00
224	0.011	0.045	0.24
223	0.077	0.294	0.26
222	0.260	0.664	0.39
221	0.138	0.472	0.29
220	0.760	1.163	0.65
219	1.001	1.434	0.70
218	0.311	0.474	0.66
217	2.133	3.195	0.67
216	1.879	2.535	0.74
215	0.612	0.870	0.70
214	1.299	1.824	0.71
213	0.985	1.679	0.59
212	0.495	0.907	0.55
211	0.653	1.496	0.44
210	1.078	1.709	0.63
209	0.802	1.388	0.58
208	1.560	2.210	0.71
	14.053	22.358	0.63

Table 6
California Coastal Kelp Resources
Monterey Bay National Marine Sanctuary
Kelp Bed Canopy/Planimeter Area/RDI
Summer 1999 and 2000

CDF&G KELP BED NUMBERS	1999 Canopy Area (sq. mi.)	2000 Canopy Area (sq. mi.)	1999 Planimeter Area (sq. mi.)	2000 Planimeter Area (sq. mi.)	1999 Rel. Dens. Ind. (RDI)	2000 Rel. Dens. Ind. (RDI)
225	0.000	0.002	0.000	0.024	0.00	0.11
224	0.011	0.019	0.045	0.083	0.24	0.22
223	0.077	0.094	0.294	0.361	0.26	0.26
222	0.260	0.583	0.664	1.060	0.39	0.55
221	0.138	0.423	0.472	0.630	0.29	0.67
220	0.760	1.262	1.163	1.669	0.65	0.76
219	1.001	1.296	1.434	1.494	0.70	0.87
218	0.311	0.405	0.474	0.534	0.66	0.76
217	2.133	2.120	3.195	2.777	0.67	0.76
216	1.879	2.217	2.535	2.647	0.74	0.84
215	0.612	0.614	0.870	0.891	0.70	0.69
214	1.299	1.811	1.824	2.246	0.71	0.81
213	0.985	1.355	1.679	2.037	0.59	0.67
212	0.495	0.678	0.907	0.985	0.55	0.69
211	0.653	1.249	1.496	1.858	0.44	0.67
210	1.078	1.243	1.709	1.902	0.63	0.65
209	0.802	0.895	1.388	1.562	0.58	0.57
208	1.560	1.187	2.210	1.903	0.71	0.62
	14.053	17.451	22.358	24.663	0.63	0.71

**CALIFORNIA COASTAL
KELP RESOURCES**

Bolinas Lagoon
to
Point Estero

Section 3

Figures

August 2000

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(Section 2)

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- 1.1 - By Map Number (includes "CDF&G kelp bed numbers")

Table 2 - Kelp Resource Map Index

- 2.1 - By Map Name (includes "CDF&G kelp bed numbers")

Table 3 - Geographic Features Index

- 3.1-3.10 - By Location

Table 4 - 2000 Kelp Bed Canopy/Planimeter Areas/Relative Density Index (RDI)

- 4.1 - By CDF&G Kelp Bed Number

Table 5 - 1999 Kelp Bed Canopy/Planimeter Areas/Relative Density Index (RDI)

- 5.1 - By CDF&G Kelp Bed Number

Table 6 - 1999 and 2000 Kelp Bed Canopy/Planimeter Areas/RDI

- 6.1 - By CDF&G Kelp Bed Number

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(Section 3)

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- 1.1 - August 10, 2000
- 1.2 - August 30, 2000

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- By CDF&G Kelp Bed Numbers: 208 - 225

Figure 3 - 1999 Kelp Bed Canopy/Planimeter Areas/Relative Density Index (RDI)

- By CDF&G Kelp Bed Numbers: 208 - 225

Figure 4 - 1999 and 2000 Kelp Bed Canopy/Planimeter Areas/RDI

- by CDF&G Kelp bed Numbers: 208 - 225

Computer Data File (Disk 1/1)

(Section 6)

FILE: MBNMSK00.XLS (Excel 97 Format)

T1 - MapIndNum - Kelp Resource Map Index (by Map Number)

T2 - MapIndName - Kelp Resource Map Index (by Map Name)

T3 - GeoFeat - Geographic Features Index (by Location)

T4 - CAPARDI00 - 2000 Kelp Canopy/Planimeter Area/RDI (by CDF&G bed number)

T5 - CAPARDI99 - 1999 Kelp Canopy/Planimeter Area/RDI (by CDF&G bed number)

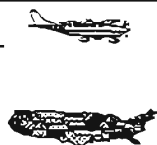
T6 - CAPARDI9900 - 1999/2000 Kelp Canopy/Planimeter Areas/RDI (by bed number)

Figure 1.1
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #
Contracting Agency: Monterey Bay National Marine Sancturay		Contract/Order #:
Division:		Agency File #:
Contact/Title: Mario Tamburi		Calendar
Address: 299 Foam St.		Services Ordered: August 1999
City/State/Zip: Monterey, CA 93940		Data Acquisition Completed: August 30, 2000
Phone 1/Phone 2: (831) 647-4206		Draft Report Materials Due:
Fax/E-Mail:		Final Report Materials Due: March 2001
Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		California Coastal Kelp Resources - Monterey National Marine Sanctuary - Summer 2000
Target Resource (s)/ Survey Range (s)		Measurement of the areal extent of coastal kelp canopies within the range of Bolinas Lagoon to Pt. Estero.
Survey Data Flow	Acquisition Processing Analysis Presentation	Vertical aerial color infrared imagery of all kelp canopies within the survey range All kelp canopies projected and rendered onto existing 1:24,000 baseline maps Area analysis of kelp canopy extent using existing CDF&G numbering system Maps presented at several sizes/formats for reporting purposes: 24"x36", 11"x17", and 8.5"x11"

Aerial Resource Survey Flight Data for:		August 10, 2000	
Survey Type/Sensing Equipment		Aircraft/Imagery Data	Associated Conditions
	Aerial Transportation/Observation	Aircraft: Cessna 182R	Sky Conditions: Clear
	Photographic Film Imagery - 35 mm	Altitude: 9,500' MSL	Sun Angle: > 45 degrees
✓	Photographic Film Imagery - 70 mm	Speed: 100 kts.	Visibility: 25 + miles
	Digital Color/Color Infrared Imagery	Camera: Pentax 645	Wind: 10 kts.
	Videography	Lenses: 75mm	Sea/Swell: 3-5 feet
	Radio Telemetry	Film: Kodak CIR	Time: 1400-1600
	Radiometry/Geophysical Measurements	Angle: Vertical	Tide: 3.0' to 3.2' (+) MLLW
	Other:	Photo Scale: 1"=3,217'	Shadow: No significant
	Sensor 1:	Pilot: Unsicker	Other: No coastal bluff shadow
	Sensor 2:	Photographer: Van Wagenen	Comments: Excellent survey cond
Range (s) Surveyed	Aerial imagery was obtained under optimum survey conditions from Rocky Pt. to Capitola		
Target Resource Observations	Kelp Canopies:	The coastal kelp canopies (both Nereocystis and Macrocystis) from Rocky Pt. to Capitola appeared well developed and at their maximum summer extent.	
Imagery Quality/ Comments	Quality:	Excellent - All kelp canopies were photographed within the above range and the subsequent film processing was conducted normally.	
	Weather Cond:	Clear	

Ecoscan Resource Data
143 Browns Valley Rd.
Watsonville, CA 95076
(831) 728-3289 (ph./fax)



Signed: _____ Bob Van Wagenen, Director

Copy To:

Figure 1.2
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #
Contracting Agency: Monterey Bay National Marine Sancturay		Contract/Order #:
Division:		Agency File #:
Contact/Title: Mario Tamburi		Calendar
Address: 299 Foam St.		Services Ordered: August 1999
City/State/Zip: Monterey, CA 93940		Data Acquisition Completed: August 30, 2000
Phone 1/Phone 2: (831) 647-4206		Draft Report Materials Due:
Fax/E-Mail:		Final Report Materials Due: October 2000
Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title	California Coastal Kelp Resources - Monterey National Marine Sanctuary - Summer 2000	
Target Resource (s)/ Survey Range (s)	Measurement of the areal extent of coastal kelp canopies within the range of Bolinas Lagoon to Pt. Estero.	
Survey Data Flow	Acquisition Processing Analysis Presentation Vertical aerial color infrared imagery of all kelp canopies within the survey range All kelp canopies projected and rendered onto existing 1:24,000 baseline maps Area analysis of kelp canopy extent using existing CDF&G numbering system Maps presented at several sizes/formats for reporting purposes: 24"x36", 11"x17", and 8.5"x11"	

Aerial Resource Survey Flight Data for:		August 30, 2000	
Survey Type/Sensing Equipment	Aircraft/Imagery Data	Associated Conditions	
Aerial Transportation/Observation	Aircraft: Cessna 182R	Sky Conditions: Clear/Cloudy (4000 ceiling)	
Photographic Film Imagery - 35 mm	Altitude: 3,500'/9,500'	Sun Angle: > 45 degrees	
✓ Photographic Film Imagery - 70 mm	Speed: 100 kts.	Visibility: 25 + miles	
Digital Color/Color Infrared Imagery	Camera: Pentax 645	Wind: 10 kts.	
Videography	Lenses: 35/75mm	Sea/Swell: 3-5 feet	
Radio Telemetry	Film: Kodak CIR	Time: 1615-1815	
Radiometry/Geophysical Measurements	Angle: Vertical	Tide: 1.1' (+) to 2.1' (+) MLLW	
Other:	Photo Scale: 1:2,540/3,217	Shadow: No significant	
Sensor 1:	Pilot: Unsicker	Other: No coastal bluff shadow	
Sensor 2:	Photographer: Van Wagenen	Comments: Excellent survey cond.	

Range (s) Surveyed	Aerial imagery was obtained under optimum survey conditions from Seaside to Pt. Estero		
Target Resource Observations	Kelp Canopies:	The coastal kelp canopies (both Nereocystis and Macrocystis) from Seaside to Pt. Estero appeared well developed and at their maximum summer extent.	
Imagery Quality/ Comments	Quality:	Excellent - All kelp canopies were photographed within the above range and the subsequent film processing was conducted normally.	
	Weather Cond:	Clear to partly cloudy conditions (4,000' MSL ceiling) prevailed throughout the survey range	

Ecscan Resource Data

143 Browns Valley Rd.
Watsonville, CA 95076
(831) 728-3289 (ph./fax)



Signed: _____ Bob Van Wagenen, Director

Copy To:

Figure 2
 California Coastal Kelp Resources
 Monterey Bay National Marine Sanctuary
 Kelp Bed Canopy/Planimeter Area/Relative Density Index
 Summer 2000
 - By CDF Kelp Bed Number

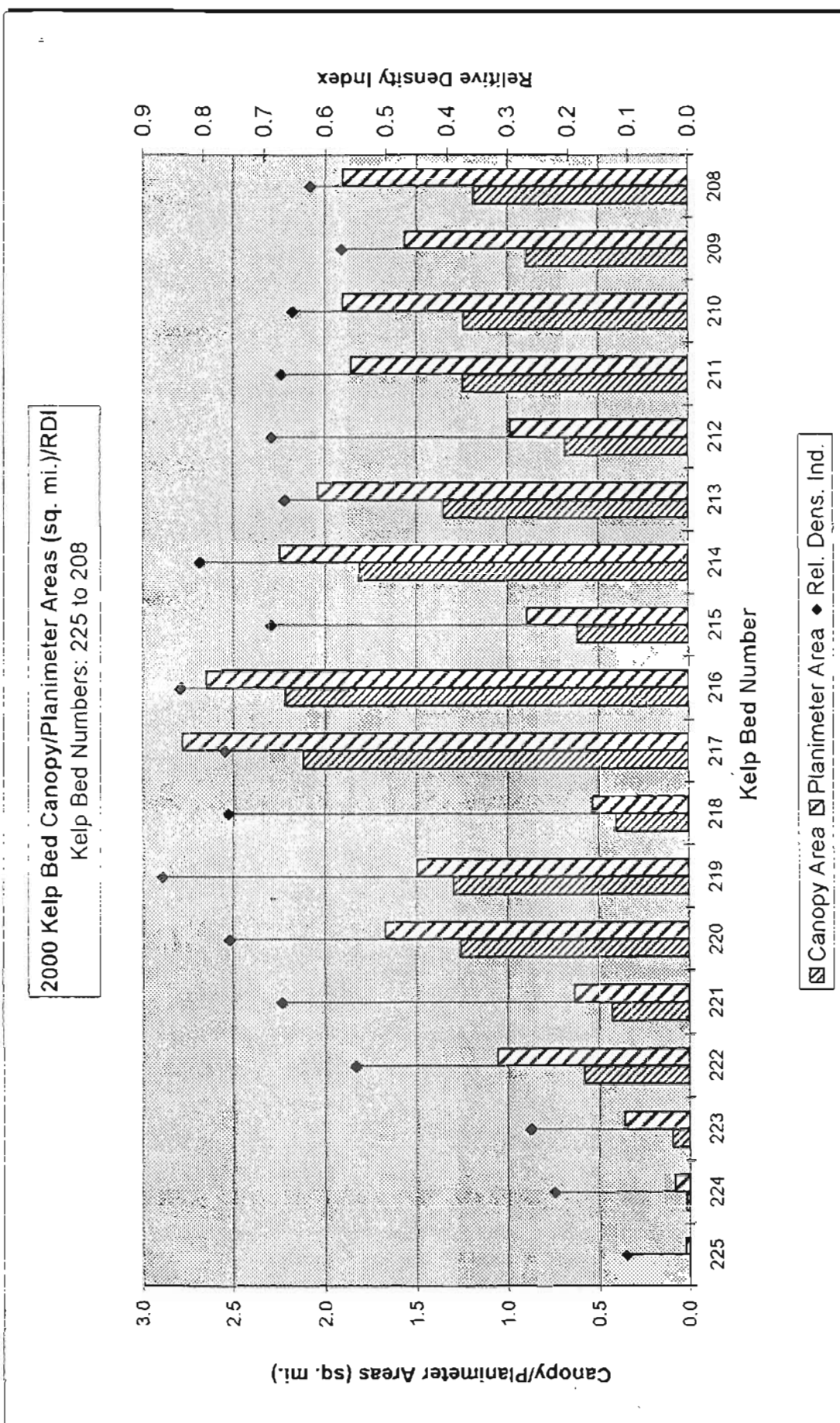
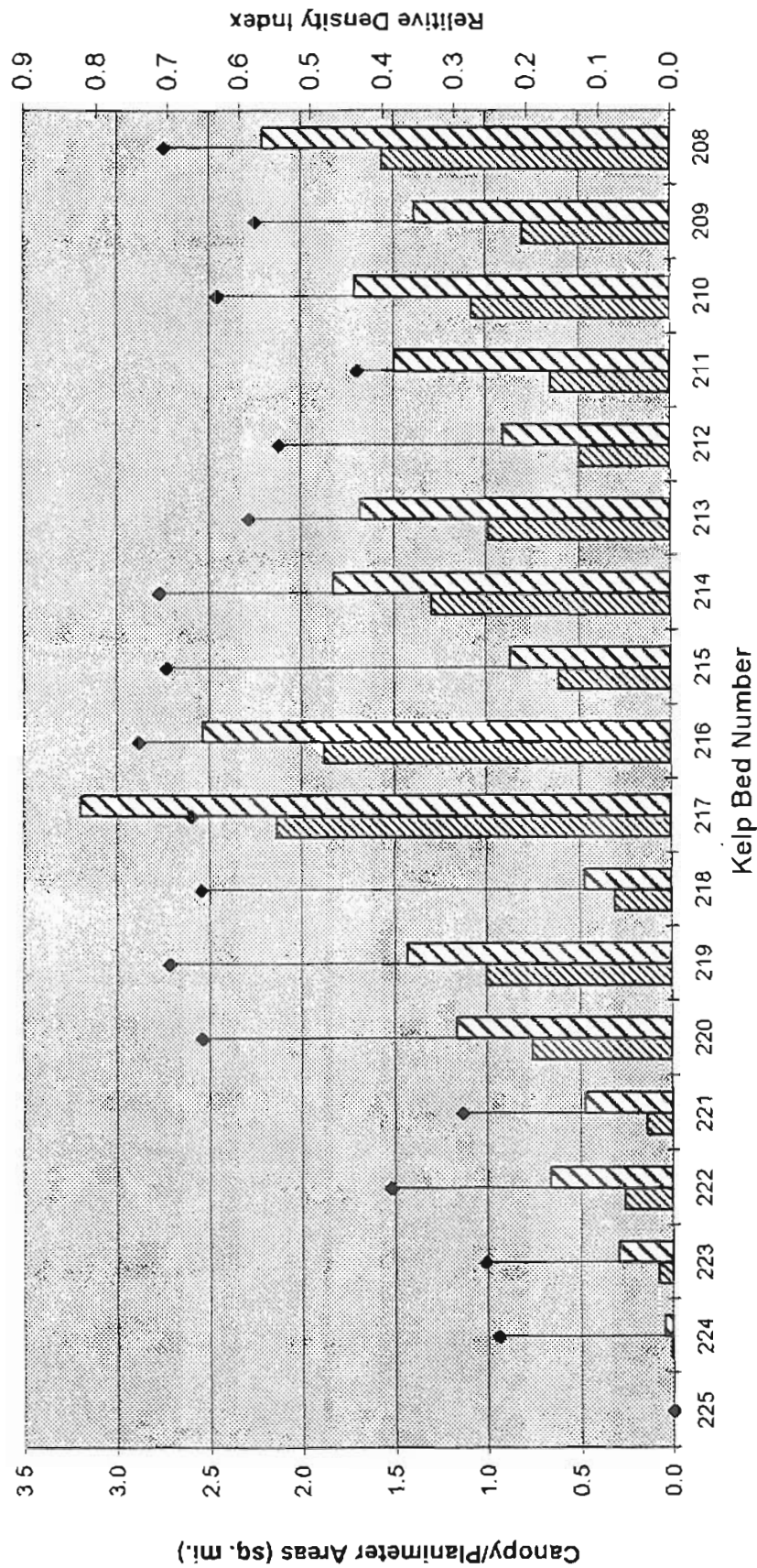


Figure 3
 California Coastal Kelp Resources
 Monterey Bay National Marine Sanctuary
 Kelp Bed Canopy/Planimeter Area/Relative Density Index
 Summer 1999
 - By CDF Kelp Bed Number

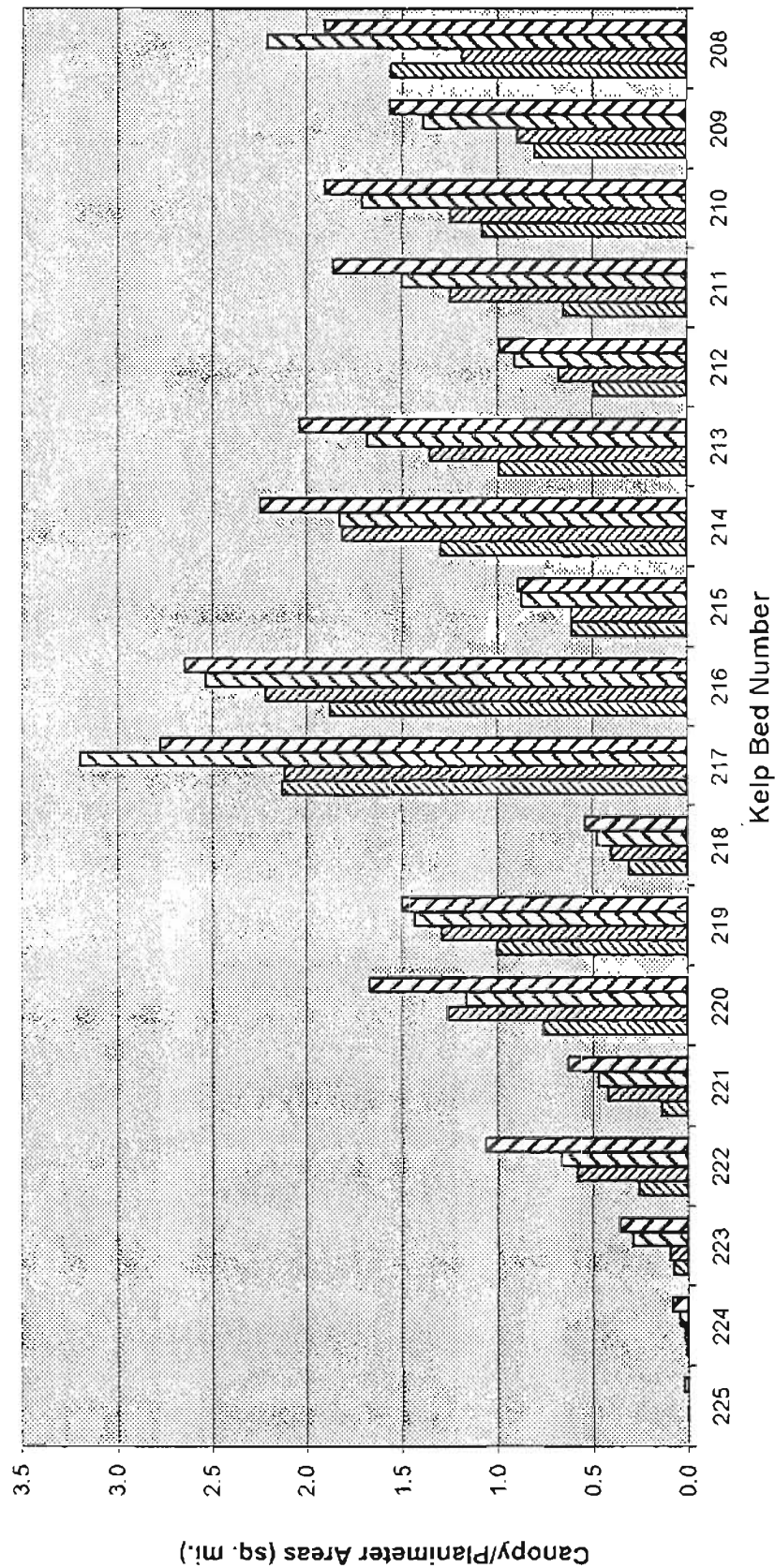
1999 Kelp Bed Canopy/Planimeter Areas (sq. mi.)/RDI
 Kelp Bed Numbers: 225 to 208



Canopy Area Planimeter Area Rel. Dens. Ind.

Figure 4
 Monterey Bay National Marine Sanctuary
 Kelp Bed Canopy/Planimeter Area
 Summer 1999 and 2000
 - By CDF Kelp Bed Number

1999 and 2000 Kelp Bed Canopy/Planimeter Areas (sq. mi.)
 Kelp Bed Numbers: 225 to 208



▨ 1999 Canopy Area ▨ 2000 Canopy Area ▨ 1999 Planimeter Area ▨ 2000 Planimeter Area

**CALIFORNIA COASTAL
KELP RESOURCES**

Bolinas Lagoon

to

Point Estero

Section 4

Kelp Bed Canopy Area Maps: 27-44

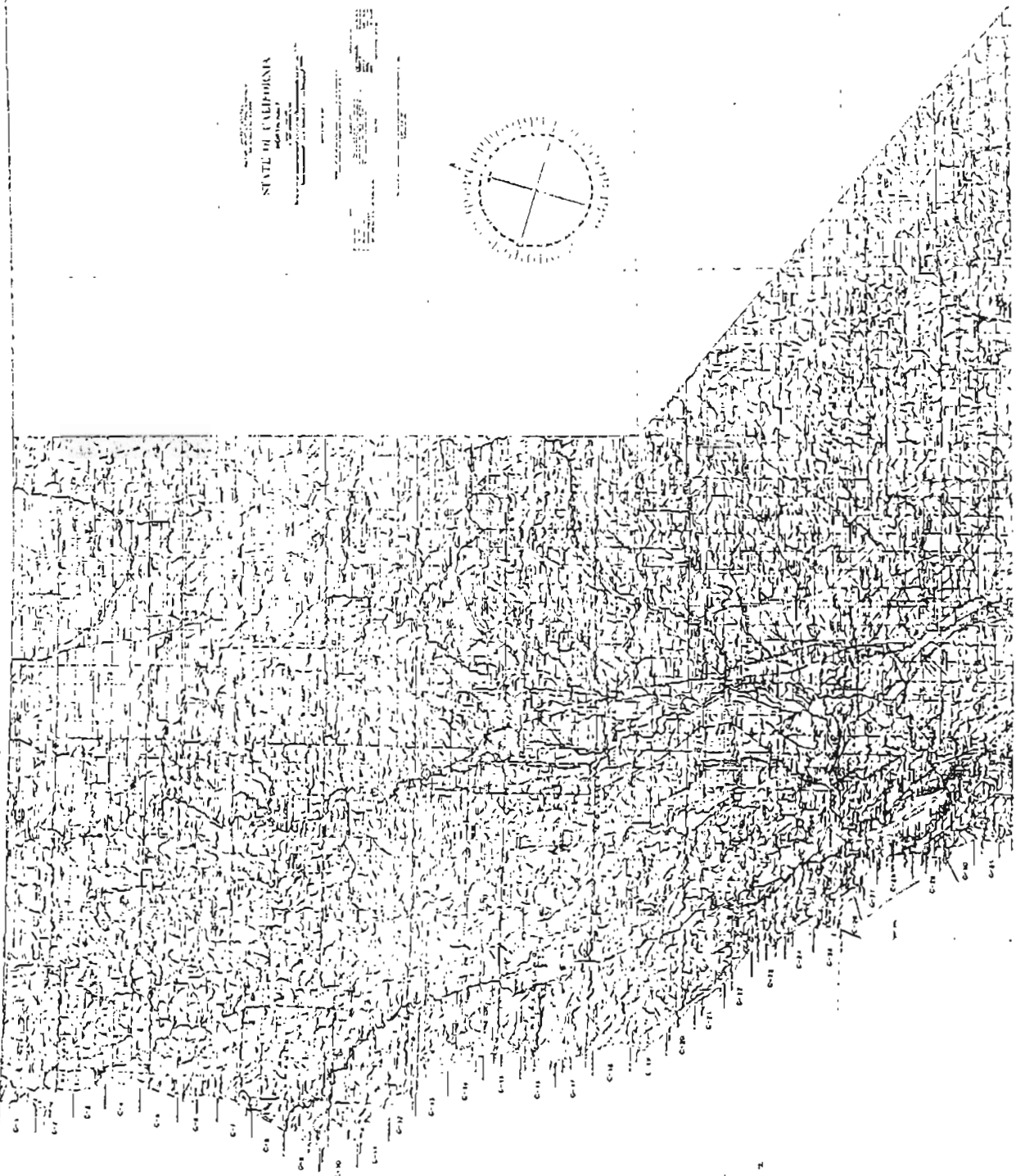
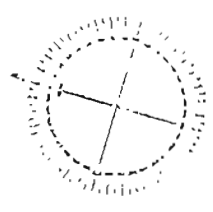
August 2000

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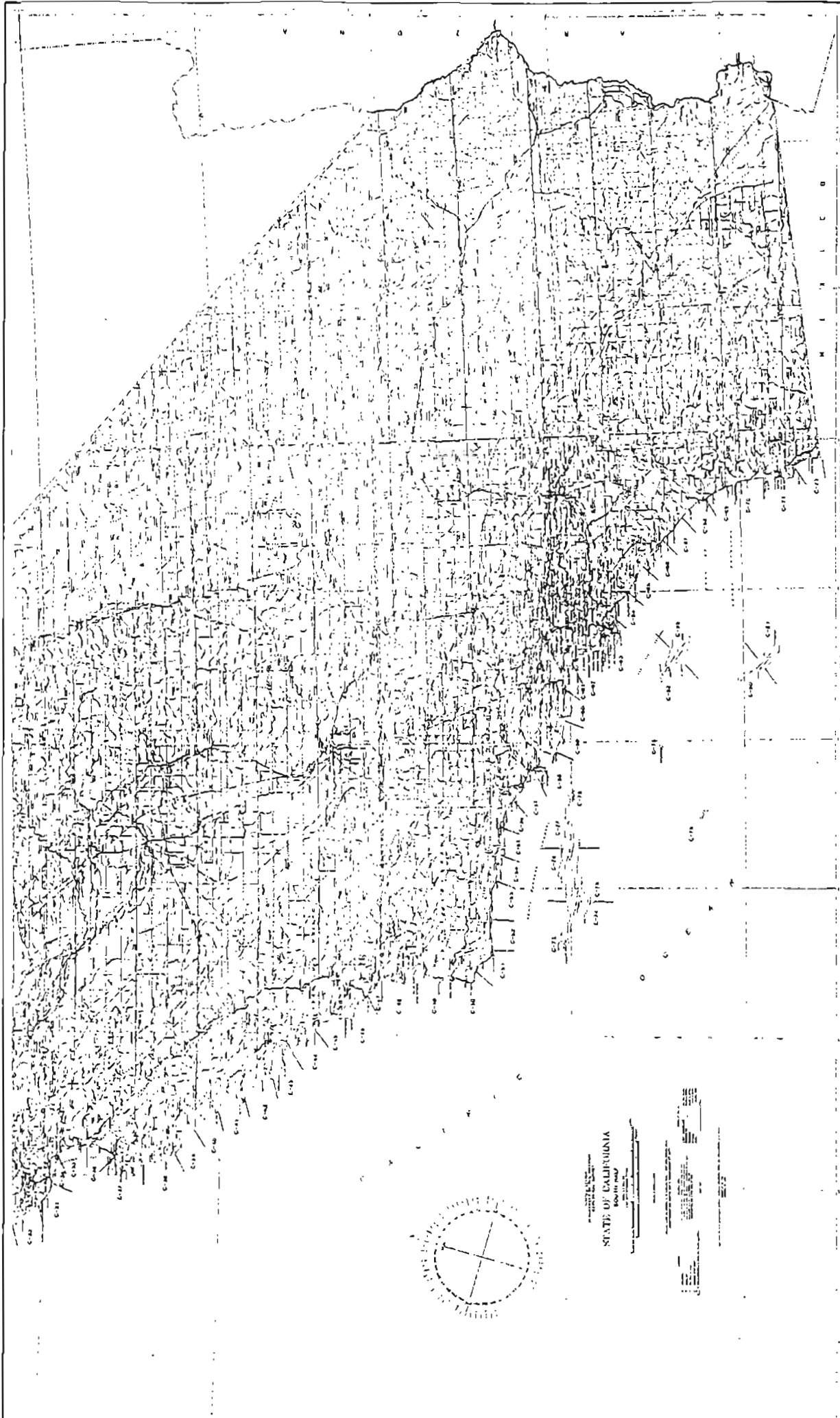
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STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF HYDROLOGY
DIVISION OF WATER RESOURCES

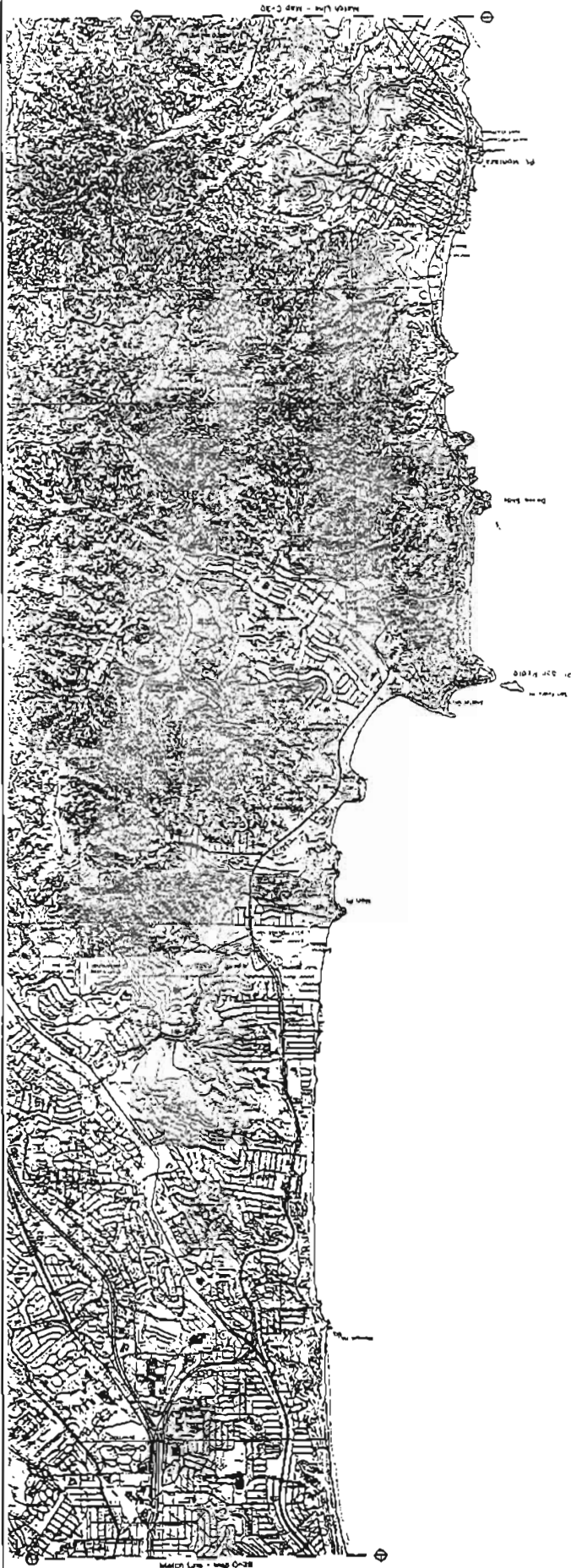


CALIFORNIA COASTAL Kelp RESOURCES	
Scale: 1:1,000,000	Map No. 1
Map No. 1	
Scale: 1:1,000,000	



STATE OF CALIFORNIA
South Bay

CALIFORNIA COASTAL HELP RESOURCES	
Map Number	MAP NO. 1 - 1
Map Scale	1" = 600,000"



1 - Kelp Bed - 1000'

2 - Kelp Bed - 1000'

3 - Kelp Bed - 1000'

4 - Kelp Bed - 1000'

5 - Kelp Bed - 1000'

6 - Kelp Bed - 1000'

7 - Kelp Bed - 1000'

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30 - Kelp Bed - 1000'

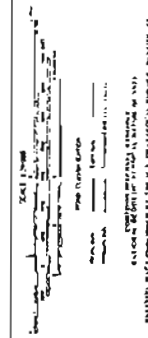
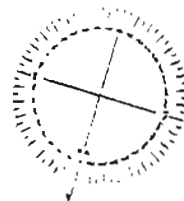
31 - Kelp Bed - 1000'

32 - Kelp Bed - 1000'

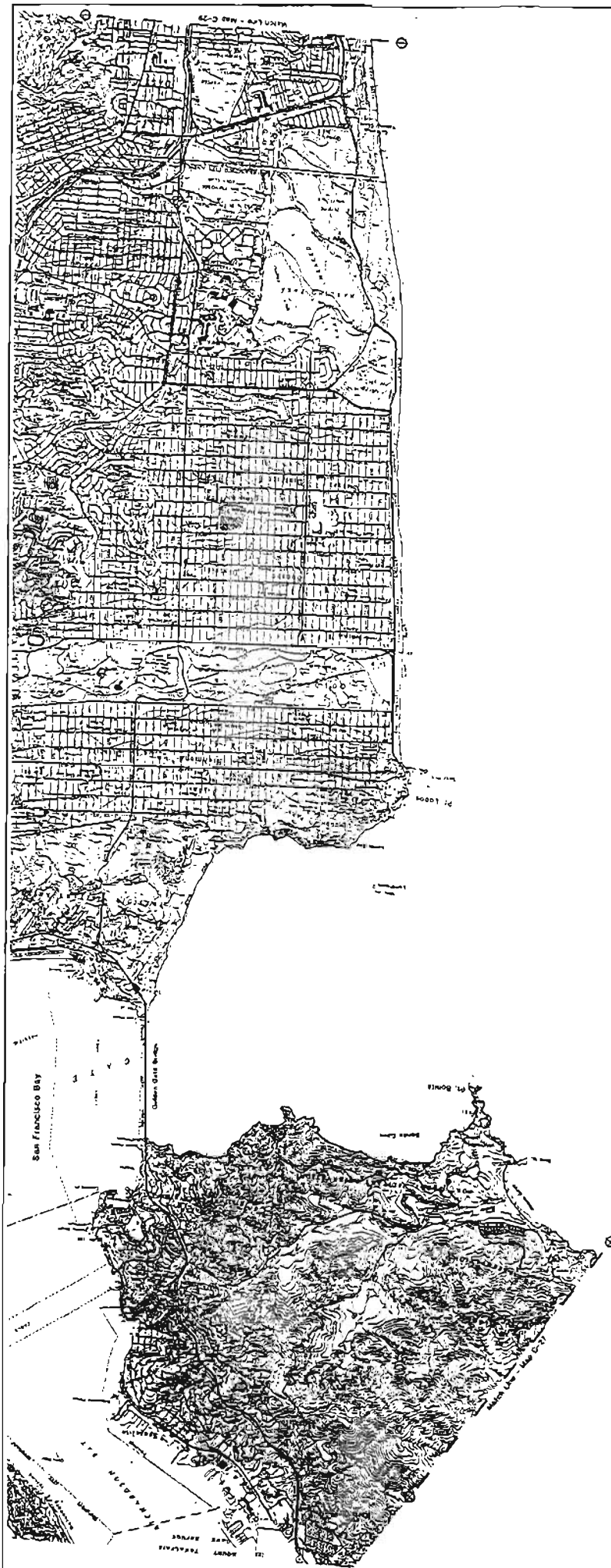
33 - Kelp Bed - 1000'

34 - Kelp Bed - 1000'

35 - Kelp Bed - 1000'



LEGEND
 1 - OFFSHORE Kelp Resources
 2 - Kelp Resource Zone
 3 - Kelp Resource Zone
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 33 - Kelp Resource Zone
 34 - Kelp Resource Zone
 35 - Kelp Resource Zone



CALIFORNIA COASTAL Kelp RESOURCES

0697-8000

Answer: 100%

SAN FRANCISCO

ECO503

C - 28

QUESTIONS

SECRET
SECURITY INFORMATION

100

1947-1948 1949-1950 1951-1952 1953-1954 1955-1956 1957-1958 1959-1960 1961-1962 1963-1964 1965-1966 1967-1968 1969-1970 1971-1972 1973-1974 1975-1976 1977-1978 1979-1980 1981-1982 1983-1984 1985-1986 1987-1988 1989-1990 1991-1992 1993-1994 1995-1996 1997-1998 1999-2000 2001-2002 2003-2004 2005-2006 2007-2008 2009-2010 2011-2012 2013-2014 2015-2016 2017-2018 2019-2020 2021-2022 2023-2024 2025-2026 2027-2028 2029-2030 2031-2032 2033-2034 2035-2036 2037-2038 2039-2040 2041-2042 2043-2044 2045-2046 2047-2048 2049-2050 2051-2052 2053-2054 2055-2056 2057-2058 2059-2060 2061-2062 2063-2064 2065-2066 2067-2068 2069-2070 2071-2072 2073-2074 2075-2076 2077-2078 2079-2080 2081-2082 2083-2084 2085-2086 2087-2088 2089-2090 2091-2092 2093-2094 2095-2096 2097-2098 2099-2100 2101-2102 2103-2104 2105-2106 2107-2108 2109-2110 2111-2112 2113-2114 2115-2116 2117-2118 2119-2120 2121-2122 2123-2124 2125-2126 2127-2128 2129-2130 2131-2132 2133-2134 2135-2136 2137-2138 2139-2140 2141-2142 2143-2144 2145-2146 2147-2148 2149-2150 2151-2152 2153-2154 2155-2156 2157-2158 2159-2160 2161-2162 2163-2164 2165-2166 2167-2168 2169-2170 2171-2172 2173-2174 2175-2176 2177-2178 2179-2180 2181-2182 2183-2184 2185-2186 2187-2188 2189-2190 2191-2192 2193-2194 2195-2196 2197-2198 2199-2200 2201-2202 2203-2204 2205-2206 2207-2208 2209-2210 2211-2212 2213-2214 2215-2216 2217-2218 2219-2220 2221-2222 2223-2224 2225-2226 2227-2228 2229-2230 2231-2232 2233-2234 2235-2236 2237-2238 2239-2240 2241-2242 2243-2244 2245-2246 2247-2248 2249-2250 2251-2252 2253-2254 2255-2256 2257-2258 2259-2260 2261-2262 2263-2264 2265-2266 2267-2268 2269-2270 2271-2272 2273-2274 2275-2276 2277-2278 2279-2280 2281-2282 2283-2284 2285-2286 2287-2288 2289-2290 2291-2292 2293-2294 2295-2296 2297-2298 2299-2300 2301-2302 2303-2304 2305-2306 2307-2308 2309-2310 2311-2312 2313-2314 2315-2316 2317-2318 2319-2320 2321-2322 2323-2324 2325-2326 2327-2328 2329-2330 2331-2332 2333-2334 2335-2336 2337-2338 2339-2340 2341-2342 2343-2344 2345-2346 2347-2348 2349-2350 2351-2352 2353-2354 2355-2356 2357-2358 2359-2360 2361-2362 2363-2364 2365-2366 2367-2368 2369-2370 2371-2372 2373-2374 2375-2376 2377-2378 2379-2380 2381-2382 2383-2384 2385-2386 2387-2388 2389-2390 2391-2392 2393-2394 2395-2396 2397-2398 2399-2400 2401-2402 2403-2404 2405-2406 2407-2408 2409-2410 2411-2412 2413-2414 2415-2416 2417-2418 2419-2420 2421-2422 2423-2424 2425-2426 2427-2428 2429-2430 2431-2432 2433-2434 2435-2436 2437-2438 2439-2440 2441-2442 2443-2444 2445-2446 2447-2448 2449-2450 2451-2452 2453-2454 2455-2456 2457-2458 2459-2460 2461-2462 2463-2464 2465-2466 2467-2468 2469-2470 2471-2472 2473-2474 2475-2476 2477-2478 2479-2480 2481-2482 2483-2484 2485-2486 2487-2488 2489-2490 2491-2492 2493-2494 2495-2496 2497-2498 2499-2500 2501-2502 2503-2504 2505-2506 2507-2508 2509-2510 2511-2512 2513-2514 2515-2516 2517-2518 2519-2520 2521-2522 2523-2524 2525-2526 2527-2528 2529-2530 2531-2532 2533-2534 2535-2536 2537-2538 2539-2540 2541-2542 2543-2544 2545-2546 2547-2548 2549-2550 2551-2552 2553-2554 2555-2556 2557-2558 2559-2560 2561-2562 2563-2564 2565-2566 2567-2568 2569-2570 2571-2572 2573-2574 2575-2576 2577-2578 2579-2580 2581-2582 2583-2584 2585-2586 2587-2588 2589-2590 2591-2592 2593-2594 2595-2596 2597-2598 2599-2600 2601-2602 2603-2604 2605-2606 2607-2608 2609-2610 2611-2612 2613-2614 2615-2616 2617-2618 2619-2620 2621-2622 2623-2624 2625-2626 2627-2628 2629-2630 2631-2632 2633-2634 2635-2636 2637-2638 2639-2640 2641-2642 2643-2644 2645-2646 2647-2648 2649-2650 2651-2652 2653-2654 2655-2656 2657-2658 2659-2660 2661-2662 2663-2664 2665-2666 2667-2668 2669-2670 2671-2672 2673-2674 2675-2676 2677-2678 2679-2680 2681-2682 2683-2684 2685-2686 2687-2688 2689-2690 2691-2692 2693-2694 2695-2696 2697-2698 2699-2700 2701-2702 2703-2704 2705-2706 2707-2708 2709-2710 2711-2712 2713-2714 2715-2716 2717-2718 2719-2720 2721-2722 2723-2724 2725-2726 2727-2728 2729-2730 2731-2732 2733-2734 2735-2736 2737-2738 2739-2740 2741-2742 2743-2744 2745-2746 2747-2748 2749-2750 2751-2752 2753-2754 2755-2756 2757-2758 2759-2760 2761-2762 2763-2764 2765

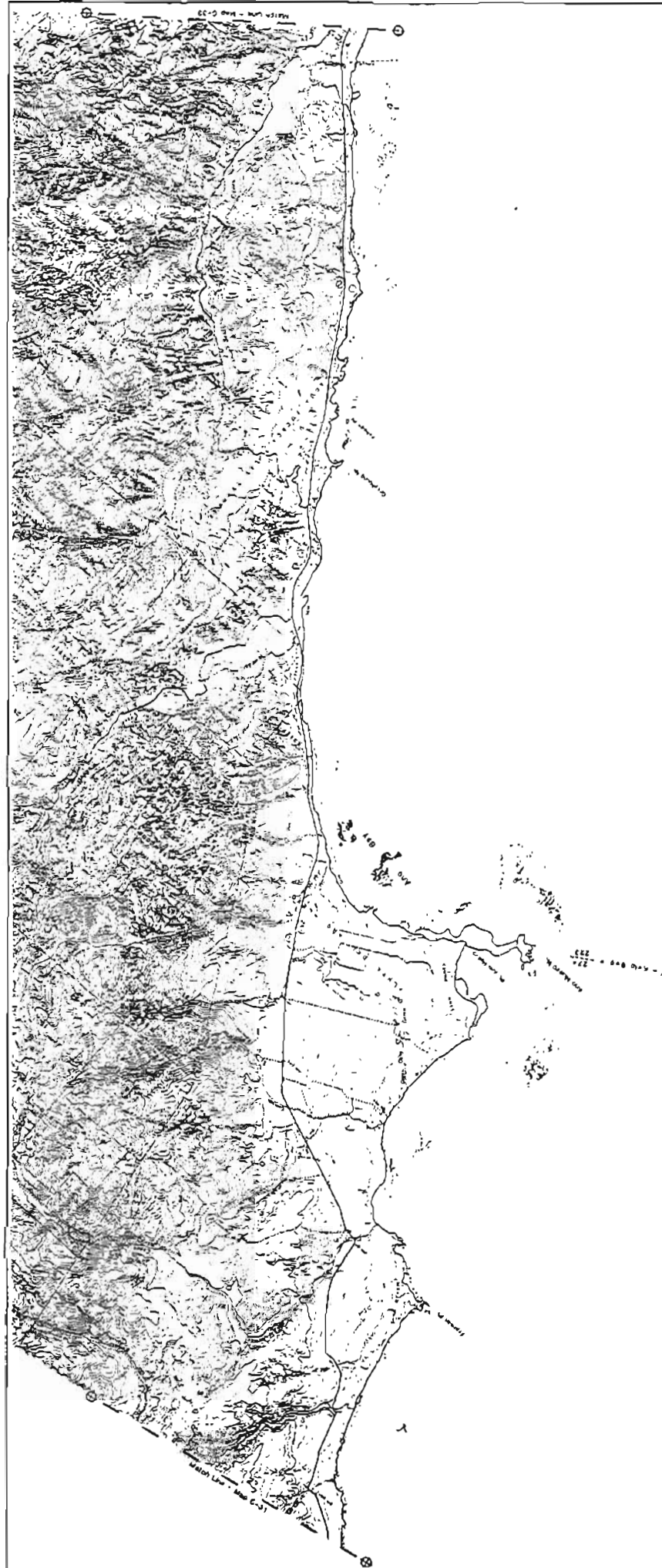
DATE: 10/10/2013

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111



LEGEND

- MAJOR ROADS
- MINOR ROADS
- WATER BODIES
- ELEVATION CONTOURS

Scale

1 inch = 1 mile

1 centimeter = 1 kilometer

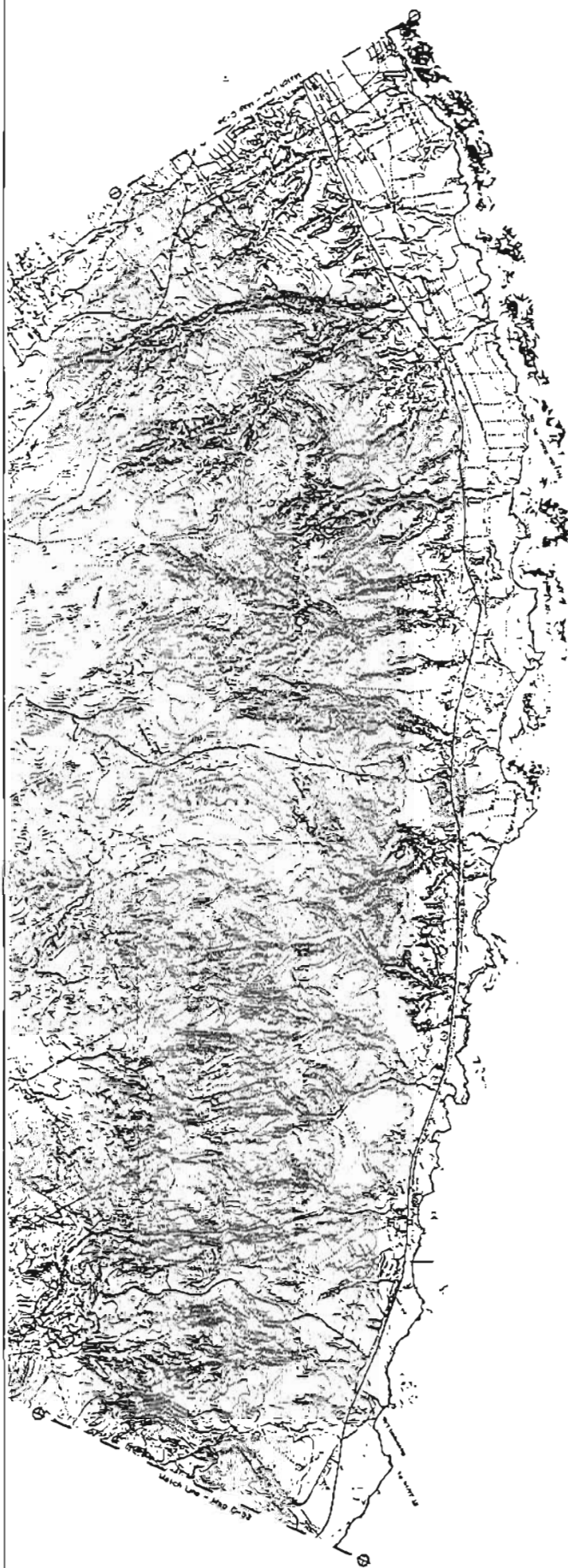
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Map C-13

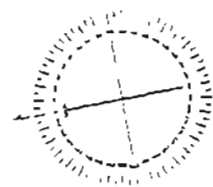
CALIFORNIA COASTAL KILP RESOURCES	
Scale: 1:62,500	Sheet: 1 of 10
Date: 1960	
Author: [Name]	
Title: [Title]	

UCS-133 -

Map C-13



SECRET - EYES ONLY



VOLUME 1

Hauptbestandteile des	
Bestandteil	Anteil
Wasser	70 %
Protein	10 %
Glukose	10 %
Mineralstoffe	10 %

Wolfe, J. D. 1993. *How to Write a Thesis*. 3rd ed. New York: Norton.

643037

SALES - **UNITED AIR CARRIERS**

MOORE & MILNER 2004

Συνολικά 21000

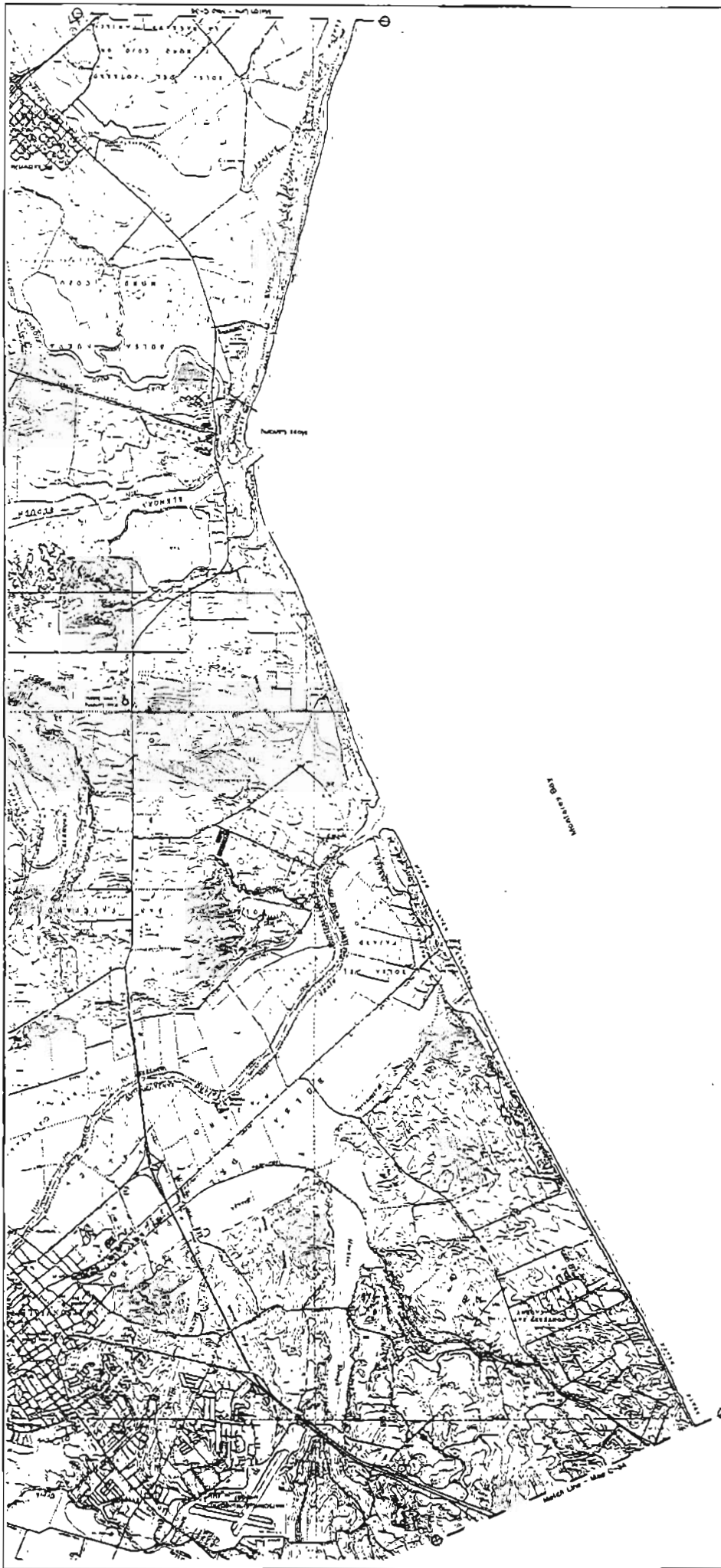
NEW YORK

CALIFORNIA COASTAL KELP RESOURCES

BOOK NO 175
ODD 72 1

Примечания

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SECTION 1
OFFSHORE Kelp Canopies
Project: Moss Landing
Date: 12/1/2000
Scale: 1:25,000
Map: Moss Landing

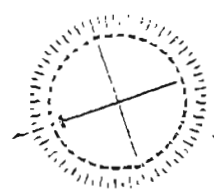
Scale: 1:25,000
Map: Moss Landing
Date: 12/1/2000
Scale: 1:25,000
Map: Moss Landing

CALIFORNIA COASTAL Kelp RESOURCES
Date: 12/1/2000
Scale: 1:25,000
Map: Moss Landing
Page: 15



2 - Kelp Bed = 210

1 - Kelp Bed = 210



LEGEND

- DITCH AND CAMP
- RIDGE AND WATERWAY
- DRY AND NO WATERWAY
- SAND AND ROCK

Scale

1 inch = 1 mile

1 inch = 1000 feet

1 inch = 1600 meters

1 inch = 2000 yards

1 inch = 3000 meters

1 inch = 4000 yards

1 inch = 5000 meters

1 inch = 6000 yards

1 inch = 7000 meters

1 inch = 8000 yards

1 inch = 9000 meters

1 inch = 10000 yards

1 inch = 11000 meters

1 inch = 12000 yards

1 inch = 13000 meters

1 inch = 14000 yards

1 inch = 15000 meters

1 inch = 16000 yards

1 inch = 17000 meters

1 inch = 18000 yards

1 inch = 19000 meters

1 inch = 20000 yards

1 inch = 21000 meters

1 inch = 22000 yards

1 inch = 23000 meters

1 inch = 24000 yards

1 inch = 25000 meters

1 inch = 26000 yards

1 inch = 27000 meters

1 inch = 28000 yards

1 inch = 29000 meters

1 inch = 30000 yards

1 inch = 31000 meters

1 inch = 32000 yards

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1 inch = 34000 yards

1 inch = 35000 meters

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1 inch = 38000 yards

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1 inch = 40000 yards

1 inch = 41000 meters

1 inch = 42000 yards

1 inch = 43000 meters

1 inch = 44000 yards

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1 inch = 49000 meters

1 inch = 50000 yards

1 inch = 51000 meters

1 inch = 52000 yards

1 inch = 53000 meters

1 inch = 54000 yards

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1 inch = 56000 yards

1 inch = 57000 meters

1 inch = 58000 yards

1 inch = 59000 meters

1 inch = 60000 yards

1 inch = 61000 meters

1 inch = 62000 yards

1 inch = 63000 meters

1 inch = 64000 yards

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1 inch = 66000 yards

1 inch = 67000 meters

1 inch = 68000 yards

1 inch = 69000 meters

1 inch = 70000 yards

1 inch = 71000 meters

1 inch = 72000 yards

1 inch = 73000 meters

1 inch = 74000 yards

1 inch = 75000 meters

1 inch = 76000 yards

1 inch = 77000 meters

1 inch = 78000 yards

1 inch = 79000 meters

1 inch = 80000 yards

1 inch = 81000 meters

1 inch = 82000 yards

1 inch = 83000 meters

1 inch = 84000 yards

1 inch = 85000 meters

1 inch = 86000 yards

1 inch = 87000 meters

1 inch = 88000 yards

1 inch = 89000 meters

1 inch = 90000 yards

1 inch = 91000 meters

1 inch = 92000 yards

1 inch = 93000 meters

1 inch = 94000 yards

1 inch = 95000 meters

1 inch = 96000 yards

1 inch = 97000 meters

1 inch = 98000 yards

1 inch = 99000 meters

1 inch = 100000 yards

CALIFORNIA COASTAL A&P RESOURCES

Scale: 1:10,000

Projection: UTM

Zone: 18N

Datum: NAD 83

Units: Feet

Plotted: 1/1

Scale: 1:10,000

Projection: UTM

Zone: 18N

Datum: NAD 83

Units: Feet

Plotted: 1/1

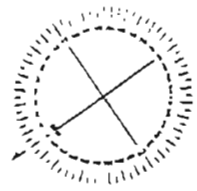


CALIFORNIA COASTAL Kelp RESOURCES

Scale: 1:25,000
 Date: 8/23/2000
 Project: Rugged Pt.
 Sheet: 1 of 12

LEGEND

- OFFSHORE Kelp CAMPUSES
- ROCKY INTERSTIAL ZONE
- OFFSHORE Kelp RESOURCES
- Seaton Pt.
- Seaton Bay



Notes

1. This map was prepared by the U.S. Geological Survey, Menlo Park, CA.

2. The map shows the distribution of kelp resources in the Seaton Bay area.

3. The map was prepared using data from the Seaton Bay Kelp Survey.

4. The map was prepared using data from the Seaton Bay Kelp Survey.

**CALIFORNIA COASTAL
KELP RESOURCES**

Bolinas Lagoon

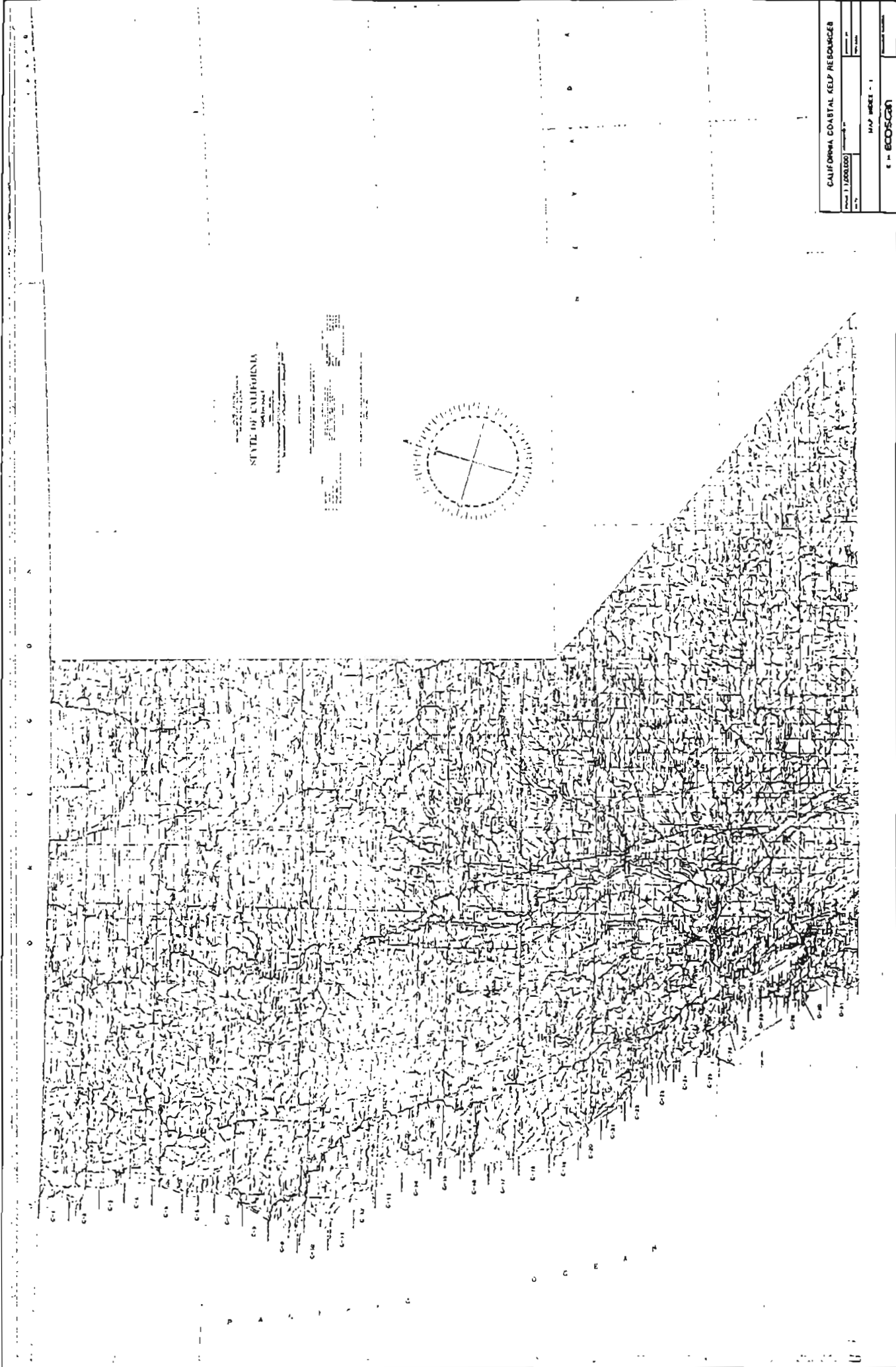
to

Point Estero

Section 5

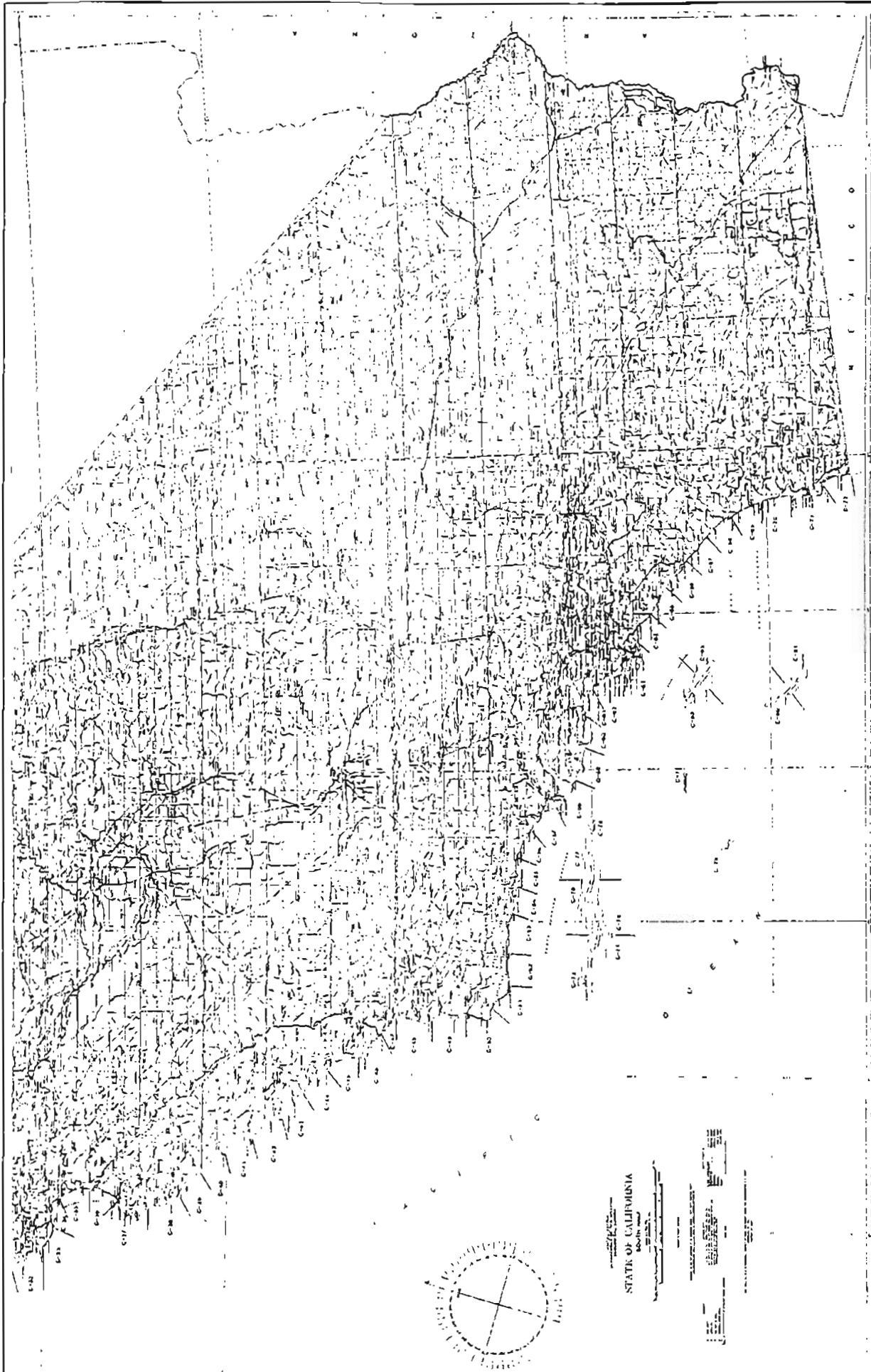
Kelp Bed Canopy Area Maps: 27-44

October 1999



STATE OF CALIFORNIA

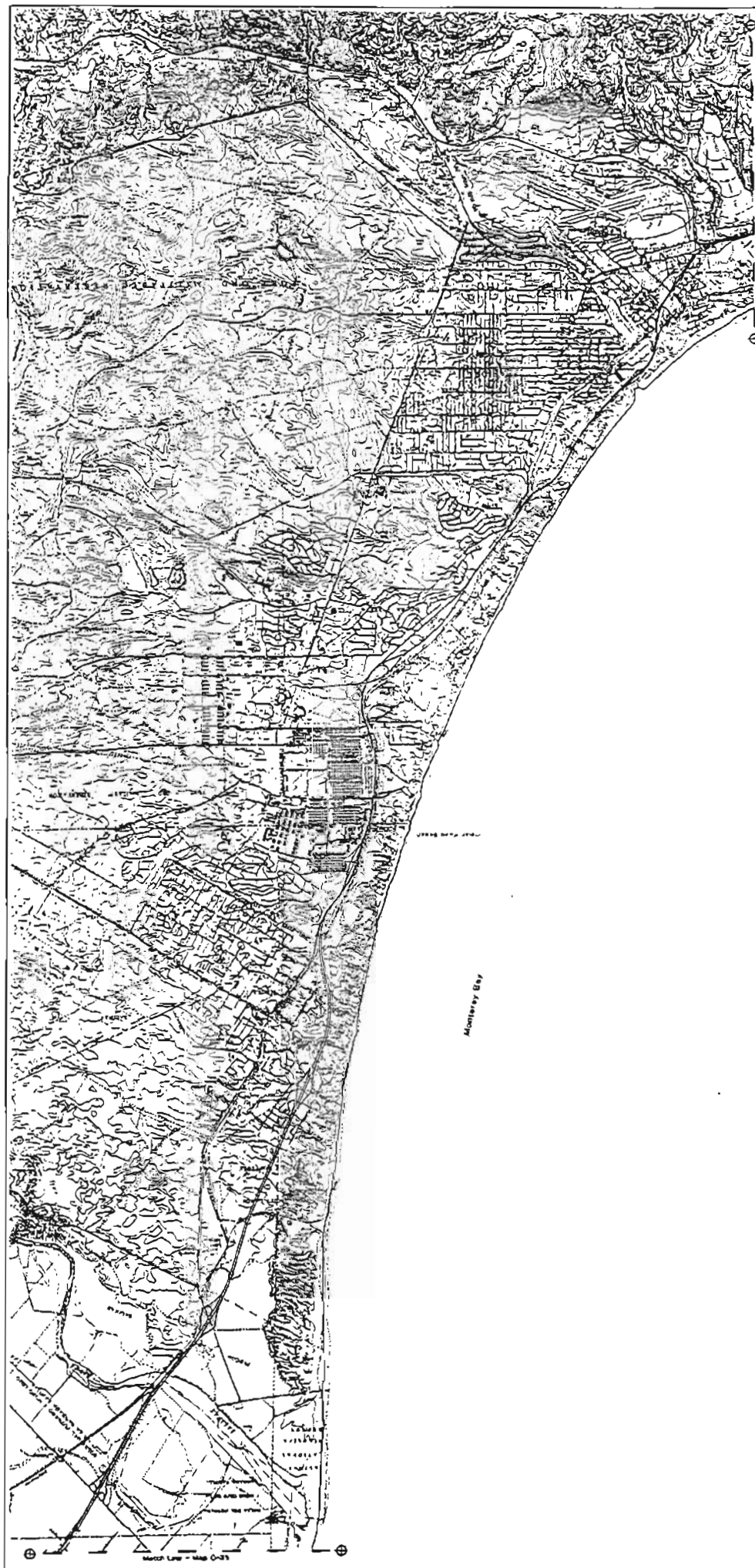
CALIFORNIA COASTAL KELP RESOURCES	
Project 1 100000	Scale 1:100000
Map Sheet - 1	
Sheet 1 of 1	



STATE OF CALIFORNIA

CALIFORNIA COASTAL Kelp RESOURCES

MAP INDEX - 2
6-86050500



LEGEND

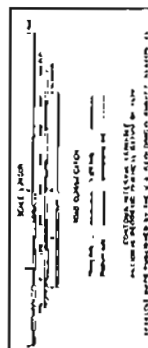
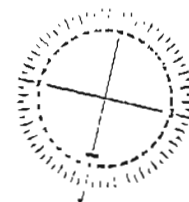
WILDLIFE PROTECTED AREAS

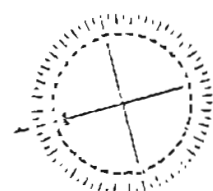
ADMINISTRATIVE ZONE

ROAD NETWORK

TOPOGRAPHY

CALIFORNIA COASTAL AID RESOURCES		Mexico	ECOSCAN	C - 36
AMOUNT \$ 174,000	\$COUNTRY			
BUDGETED				





LEGEND

- OFFSHORE OIL DERRICK
- NAVIGATIONAL BUOY
- OFFSHORE AQUEDUCT
- BEACH

Scale 1:50,000

Scale Bar: 0 to 1 mile

North Arrow: Points North

Projection: UTM Zone 18N

Datum: NAD 83

Units: Feet

Source: U.S. Geological Survey, 1980

CALIFORNIA COASTAL Kelp RESOURCES

Map No. 1234567

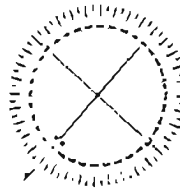
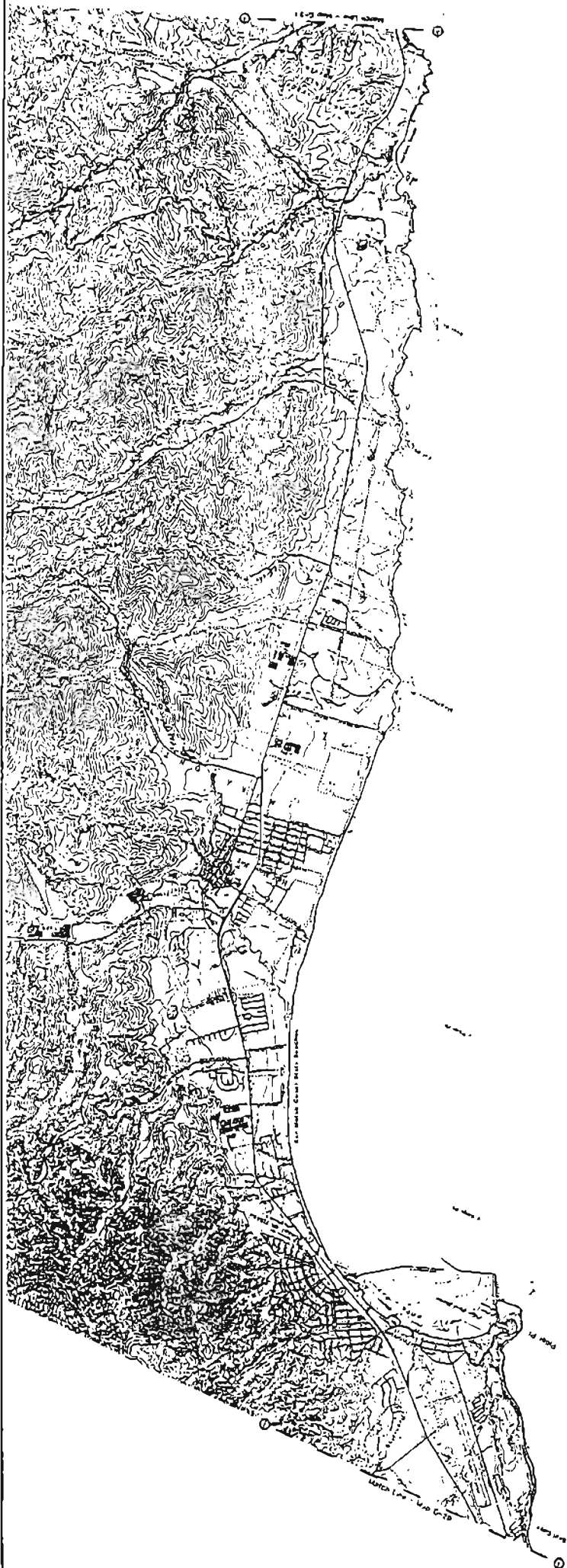
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Sheet: 10000

Version: 1.0

Page: 1 of 1

Project: C-27



LEGEND

CONTOUR LINES
 ROADS
 BUILDINGS
 WATER BODIES

Scale 1:50,000

0 1 2 3 4 5 6 7 8 9 10
 Kilometers
 0 1 2 3 4 5 6 7 8 9 10
 Miles

Contour Interval: 20 Feet
 Projection: UTM
 Datum: WGS 84
 Date: 1984

CALIFORNIA COASTAL Kelp Resources	
Scale: 1:50,000	Date: 1984
Map Name: Malibu Bay	
Sheet: C - 30	



LEGEND

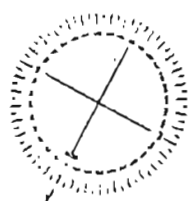
OFFICIAL MAP SYMBOLS

ROAD WITHIN 100'

ONE-POLE ROADWAY

ROAD MARK

CALIFORNIA COASTAL KELP RESOURCES	
Scale	1:25,000
Sheet	10011
Project	Pigeon Pt.
Author	ECOSCAN
Version	0 - 31



Map Notes	
Scale	1:25,000
Sheet	10011
Project	Pigeon Pt.
Author	ECOSCAN
Version	0 - 31
Notes	1. This map is a topographic map of the Pigeon Pt. area. It shows the coastline, roads, and other features. The map is oriented with North at the top.

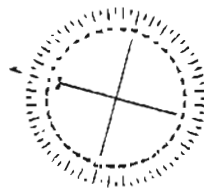


(- ROAD DIST - 22.1

Santa Cruz Harbor

Santa Cruz City

March Line - 1988 C-33



LEGEND

- OFFSHORE REEF MARKERS
- ROCKY INTERIOR TIDE
- OFFSHORE REEF MARKERS
- SAND BEACH

Scale 1:25,000

Map Data:

- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River
- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River

Map Data:

- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River
- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River

Map Data:

- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River
- Map Data: Santa Cruz Harbor
- Map Data: Santa Cruz City
- Map Data: Santa Cruz River

CALIFORNIA COASTAL Kelp Resources

Scale: 1:25,000

Year: 1978

Map Data:

- Map Data: Santa Cruz
- Map Data: Santa Cruz
- Map Data: Santa Cruz

Map Data:

- Map Data: Santa Cruz
- Map Data: Santa Cruz
- Map Data: Santa Cruz

Map Data:

- Map Data: Santa Cruz
- Map Data: Santa Cruz
- Map Data: Santa Cruz

C - 14



1:10,000
1:50,000

LEGEND

- BOUNDARY OF SURVEY
- ROAD
- STREAM
- SPOT ELEVATION
- SPOT ELEVATION
- SPOT ELEVATION

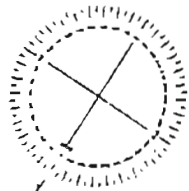
CALIFORNIA COASTAL Kelp RESOURCES

1:10,000
1:50,000

P.L. 84-160

U.S. GEOLOGICAL SURVEY

C-38



Scale 1:10,000

1:10,000
1:50,000

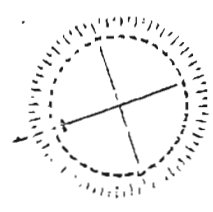
U.S. GEOLOGICAL SURVEY

C-38



Point Loma - San Diego

Point Loma - San Diego



NAME: J. AND ADDRESS: 1000 CITY: SAN DIEGO STATE: CALIFORNIA ZIP: 92101	
DATE: 10/10/71 TIME: 10:00 AM BY: J. AND	

LEGEND ELEVATION: 0 - 1000 FT. CONTOUR ROCKY TERRAIN: DOTTED LINE SAND: WAVE LINE CLIFF: DASHED LINE SAND MOUND: SOLID LINE	
--	--

CALIFORNIA COASTAL Kelp RESOURCES NAME: J. AND ADDRESS: 1000 CITY: SAN DIEGO STATE: CALIFORNIA ZIP: 92101	
DATE: 10/10/71 TIME: 10:00 AM BY: J. AND	

Scale: 1:50,000
 Date: 10/10/71
 By: J. AND

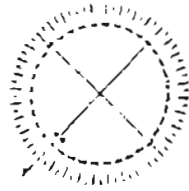


1:50,000 Scale

LEGEND

- OFFSHORE MAP SYMBOLS
- POINT OF VIEW
- OFFSHORE STRUCTURES
- LAND AREA

CALIFORNIA COASTAL Kelp RESOURCES	
Scale	1:50,000
Sheet	10/12
Cape San Martin	
C-41	



Scale	1:50,000
Sheet	10/12
Cape San Martin	
C-41	



LEGEND

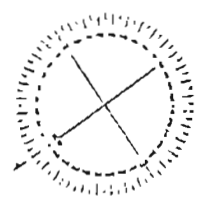
- ON-SHORE DUNE PROFILES
- ACCRETION INITIATION ZONE
- ON-SHORE ACCRETION ZONE
- BEACH

CALIFORNIA COASTAL KEMP RESOURCES

Map No. 101-1000
Scale: 1:10,000
Date: 10/19/89

Project: 101-1000
Sheet: 101-1000

By: J. J. P. L.
S. = ECOSCAN
C-41

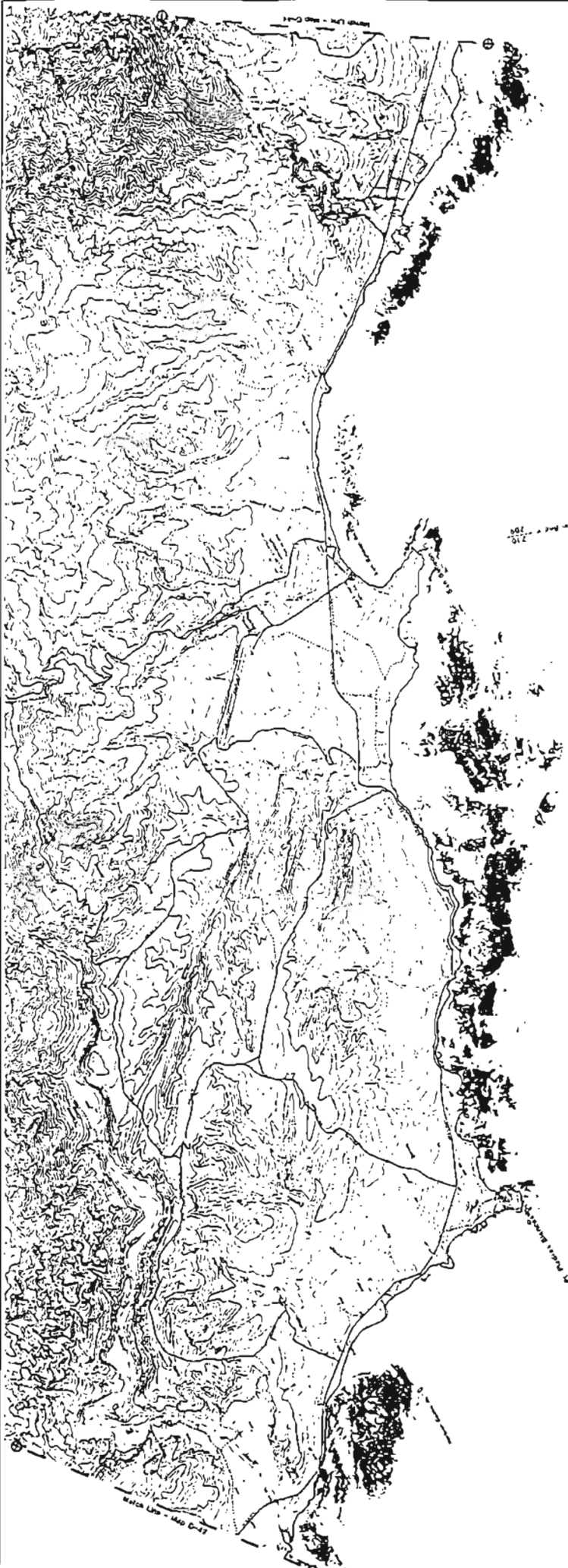


Map C-41

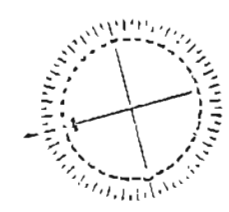
Map No. 101-1000
Scale: 1:10,000
Date: 10/19/89

Project: 101-1000
Sheet: 101-1000

By: J. J. P. L.
S. = ECOSCAN
C-41



210
114



LEGEND

- 1000' CONTOUR LINE
- 500' CONTOUR LINE
- 200' CONTOUR LINE
- 100' CONTOUR LINE
- 50' CONTOUR LINE
- 25' CONTOUR LINE
- 10' CONTOUR LINE
- 5' CONTOUR LINE
- 2' CONTOUR LINE
- 1' CONTOUR LINE
- 0' CONTOUR LINE

Map 1 of 4

Scale: 1 inch = 1 mile

Projection: UTM

Zone: 18N

Datum: WGS 84

Units: Meters

Contour Interval: 100 feet

Map Date: 1984

Map Title: Coastal Kelp Resources

Map Author: [Name]

Map Reviewer: [Name]

Map Approved: [Name]

Map Date: 1984

Map Title: Coastal Kelp Resources

Map Author: [Name]

Map Reviewer: [Name]

Map Approved: [Name]

CALIFORNIA COASTAL KELP RESOURCES

Scale: 1 inch = 1 mile

Projection: UTM

Zone: 18N

Datum: WGS 84

Units: Meters

Contour Interval: 100 feet

Map Date: 1984

Map Title: Coastal Kelp Resources

Map Author: [Name]

Map Reviewer: [Name]

Map Approved: [Name]

1 - 1000' Contour

2 - 500' Contour

3 - 200' Contour

4 - 100' Contour

5 - 50' Contour

6 - 25' Contour

7 - 10' Contour

8 - 5' Contour

9 - 2' Contour

10 - 1' Contour

